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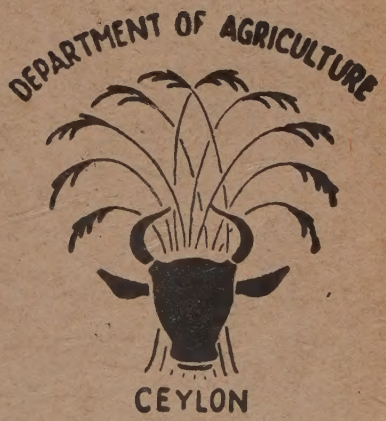

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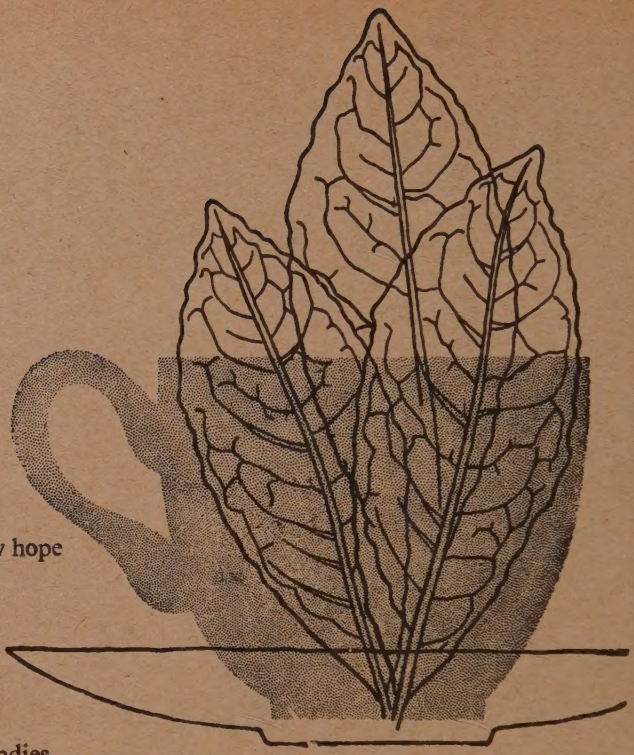

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TROPICAL AGRICULTURIST

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Vol. CXII. No. 3

CONTENTS

July–Sept. 1956

PAGE

Editorial

187 Dry Farming in Ceylon

Articles

191 Dry Land Farming in Ceylon. E. L. F. ABEYRATNE, B.Sc. (Lond.)—*Research Officer* (*Dry Farming*), *Department of Agriculture, Ceylon*

230 Farming in the Dry Zone in Ceylon—Some Observations and Comments on Problems and their Solutions. EVAN A. HARDY—*F. A. O. Technical Assistance Mission*

233 The Progress of Dry Farming Schemes in Ceylon. C. R. KARUNARATNA, Dip. Agric. (Wye), Dip. Agri. (Poona)—*Agricultural Officer, Department of Agriculture, Ceylon*

251 The Progress of Recent Breeding Work on Cotton in Ceylon. D. V. ARIYANAYAGAM, B.Sc. (Lond.)—*Botanist and Senior Research Officer* and R. T. WIJEWANTHA, B.Sc. (Lond.)—*Research Officer, Department of Agriculture, Ceylon*

262 Techniques of Seed and Seedling Production with Sugar Cane. E. W. H. JAYASEKERA, B.Sc. (Hons.), Ceylon—*Research Officer, Department of Agriculture, Ceylon*

267 A Brief Survey of Agricultural Conditions in the Sabaragamuwa Province R. E. PONNIAH, B.Sc. (Edin.), Dip. Agric. (Poona)—*Agricultural Officer Department of Agriculture, Ceylon*

276 Some Aspects of Dry Farming in the Canadian Prairies with references to Dry Farming in Ceylon. G. R. W. DIAS—*Agricultural Instructor* (*Engineering*), *Department of Agriculture, Ceylon*

EDITORIAL

Dry Farming in Ceylon

DRY FARMING is a system of agriculture which obtains in the dry zones of the world and has as its basis the maximum conservation of the very low rainfall experienced in these areas. It finds its greatest expression in parts of the U. S. A., India, Canada, U. S. S. R., etc. In Ceylon the term "dry farming" is used to connote the cultivation of annual crops on unirrigable land in the dry zone under natural rainfall conditions. In the greater part of this zone, however, the annual precipitation varies from 50 to 75 inches, but about three-fourths of this amount is experienced during a period of about four months i.e., from October to January. There is consequently a long dry and hot period when atmospheric and soil moisture conditions are not unlike those obtaining in typical dry-farming areas of tropical and semi-tropical countries.

The traditional method of cultivating unirrigable land in the dry zone of the Island is that of shifting cultivation, known locally as the "chena" system. This consists in the burning of the jungle or forest on an area of such land once in about ten to fifteen years, cultivating it for two or three seasons with a mixture of crops, mostly sown broadcast, and abandoning it thereafter till such time as the jungle has regenerated itself. This system is extremely wasteful of good agricultural land and is only possible in areas where the population is very sparse and at a bare subsistence level of existence. It is necessitated primarily because of the unsuitability of the land for implemental tillage and the inability of the cultivator, therefore, to control weeds after a short period of cultivation.

For many years the Department of Agriculture has been carrying out trials and investigations in different parts of the dry zone on the problems of dry farming. Records show that an Experiment Station was started at Maha Illuppallama in 1903, mainly with the object of determining what economic crops could be cultivated under conditions obtaining on unirrigable land in the area. Cotton, sisal, tobacco and groundnut were some of the more important crops experimented with, but the trials apparently proved unsuccessful and the station was closed down in 1919. In the early twenties, Sir Frank Stockdale, the then Director of Agriculture, established a number of experiment stations where trials were carried out to determine how best chena cultivation could be replaced by a system of rotational agriculture, as he was convinced that this type of farming could, as in South India, be successfully adopted in many parts of our dry zone. These trials gave useful information but were not conducted for a sufficiently long period or on such a scale as to give conclusive results on a number of problems relating to this subject.

In 1938, Mr. Edmund Rodrigo, when Director of Agriculture, initiated the well-known Kurundankulam dry farming pilot scheme on an area of 100 acres of unirrigable land in the Anuradhapura district. The objects of the Kurundankulam experiment were threefold : (1) to ascertain whether it was possible for the dry zone cultivator with guidance and assistance, to make a living out of arable farming as a substitute for chena cultivation on land developed and rendered suitable for such farming, (2) to determine the optimum extent of such land that an average family could farm on these lines with simple bullock-drawn implements. A long-range objective was to ascertain whether soil fertility could be maintained under the severe conditions of temperature and rainfall prevalent in the dry zone. This experiment gave such encouraging results at the early stages that it led to a considerable expansion of the area at Kurundankulam to 1,000 acres in 1950, and also to the establishment of three similar schemes at Relapanawa, Olukaranda and Makalanagama about the same time. The article by C. R. Karunaratne in this issue of the *Tropical Agriculturist* records the story of the Kurundankulam experiment and of the vicissitudes it has undergone over the years and of the other sister schemes. A careful study of the progress of these schemes would reveal that while a reasonable degree of success was achieved by the adoption of the then-known methods of and ideas on highland farming in the dry zone, there were many problems of a fundamental nature which had to be intensively studied and solved before it could be established that arable farming could be made a complete success under these conditions and embarked upon with confidence throughout other such areas of the Island. Accordingly it was decided to establish a research station in the dry zone where climatic and soil conditions would be very similar to those of the dry farming pilot schemes referred to. Maha Illuppallama, the centre of the earlier dry farming experiments was, strangely enough, ultimately selected for this purpose and in 1946, a start was made with the project on an initial extent of about 900 acres of land.

It has been estimated that there are about 1½ million acres of unirrigable land in the dry zone which would be suitable for development under some system of arable farming linked with animal husbandry. It was realised, therefore, that the work at Maha Illuppallama would be of fundamental national importance and a scheme for the development of a research station in keeping with the importance of the subject was planned. Accordingly in 1950 a Research Officer was stationed at Maha Illuppallama to survey and report on the problems relating to the project. A Committee of the Department of Agriculture was also appointed to draw up a scheme for the establishment of an up-to-date research station at Maha Illuppallama. Further, the services of an experienced expert on dry-farming problems in the person of Professor Evan A. Hardy were obtained through the agency of the Food and Agricultural Organization to guide the development of the project on sound lines. A lack of adequate funds militated, however, against the early establishment of the research station, but

thanks to the generosity of the New Zealand Government which contributed in 1952 and 1953 the magnificent sum of £500,000 under the Colombo Plan Technical Assistance Scheme the capital expenditure needed, it has been possible to build and equip a first-rate research station with laboratories, workshops, stores and farm buildings, and quarters for staff and labour, supplied with all amenities that an institution of this nature requires.

The comprehensive paper in this issue of the *Tropical Agriculturist* by Mr. E. Abeyratne, Research Officer, Dry Farming, the pioneer of this project, is worthy of careful study by everyone concerned with the development of the dry zone of the Island. It will be seen that the results obtained by Mr. Abeyratne and his associates at Maha Illuppallama during the last four years are of a far-reaching nature, but it is also interesting to note that Mr. Abeyratne is of the view that the basic principles of land use in ancient Ceylon were sound and in accordance with modern principles of land utilization. What is mainly required, apparently, is an intensification of agriculture within the existing pattern by the adoption of modern techniques adapted to the dry zone environment. His studies have led Mr. Abeyratne to the conclusion that the planning of agricultural development in the dry zone must be on the basis of individual river valleys and that the conditions there are best suited for a co-operative system of agriculture. It has also become clear from his studies that under the environmental conditions of the dry zone, a diversified system of land use is inevitable even on relatively small extents of unirrigable land. Further, it is apparent from the results so far obtained that the maintenance of soil fertility under these conditions can only be ensured by the integration of animal husbandry within the system of agriculture obtaining in the village. Artificial fertilisers have not, so far, proved of much benefit under dry zone conditions. Mechanization, it is considered, will have important implications in the development of this zone and it is suggested that this point should be clearly kept in view. These general findings are in accord with the views held by J. B. Farmer who has made a special study of the dry zone of the Island.

Certain interesting features of a technical nature need to be drawn attention to in this review. Such, for example, are the primary importance of weed control, of the maintenance of good soil structure, of timely sowing and tillage, and of a non-inversion system of tillage necessitating the use of shallow-operated tillage implements, etc., if a successful system of arable farming is to be established under our dry zone conditions. The importance of trash mulches has been clearly demonstrated and measures for obtaining optimum results under such a system of cultivation have been determined. The value of chemical weed killers has also been clearly indicated, particularly for the cultivation of upland rice which can be grown very successfully in the bottom lands of stream catchments. The moisture status of the soil has been shown to be the limiting factor of

yield in dry farming : success or failure of any cultural operation can be explained in relation to this soil characteristic, which in turn is determined by the nature and amount of its clay material and the rainfall conditions obtaining during the season. The subject of associated growth or mixed cropping has also received considerable attention but, in the main, has not been found of much benefit.

The work at Maha Illuppallama may well prove to be one of the most vital and important of the new projects that have been undertaken for the development of agricultural land in this country during the past few decades. The expenditure involved on buildings, laboratories, equipment and personnel has already been fully justified, and there is little doubt that, given time, a solution will be found for most, if not all, the problems that now hinder the adoption on a large scale of an economic system of dry farming suitable for large extents of unirrigable land in the dry zones of this Island. When this stage of progress is reached, and the systematic development of the land in the dry zone is undertaken on the lines demonstrated, there will be much scope for the profitable employment of trained personnel and labour on land of little economic value now, and a substantial contribution to the food supplies of the Island, both of plant and animal food, can be expected.

But it is necessary to emphasise that this type of farming, to be successful, will call for the qualities of hard work, grit, alertness and sustained interest in the land, to a much greater degree than is now evinced by the average cultivator in the dry zone. Economic necessity will, however, compel many to seek their livelihood from dry farming, and while a number may fail at the start, there is every reason to hope that a tradition of such farming methods will gradually be built up in the tank villages of the dry zone of the Island, and that this will once again become a land of " milk and honey ".

ARTICLES

Dry Land Farming in Ceylon

E. L. F. Abeyratne, Research Officer, Dry Farming, Department of Agriculture, Ceylon

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1. Background to the Agricultural Development of the Dry Zone. The development of plantation agriculture, notably coffee, tea, rubber and coconut in the wet zone has in the last century resulted in a change in the economy of Ceylon. Concentration on a few export products increased national income and made possible the intensification of health services which have reduced the death rate to the lowest in Asia. The rapid increase in population was inevitably followed by an increased demand for agricultural products. Up to the second World War the greater part of the Island's requirements of agricultural products was cheaply imported. This left no incentive to the development of the local agriculture and thus while the plantation industries made great strides, local agriculture remained underdeveloped. This was particularly true of the dry zone where the ravages of malaria had helped to keep it more or less economically and agriculturally isolated for over seven hundred years.

The second World War altered this situation. The enforced restriction of imports and the inflationary trends within the country created increased demands which placed a heavy strain on local agriculture. At the same time population increases in the wet zone began to create increasing demands for land. To meet this deteriorating situation an attempt had to be made to crowd into a few years an agricultural development that should have occurred graually over a century or so. Agricultural expansion in the wet zone is limited. Out of the Island's total area of 16,210,000 acres, 6,712,000 acres are cultivable of which 3,500,000 are already under clutivation (2,800,000 acres in the wet zone and 700,000 acres in the dry zone). The balance available for future agricultural development is 3,250,000 acres. Almost all this land is in the dry zone and as practically the whole of this area is in forest it is safe to assume that most of the extent is crown land (1). Here in this sparsely populated, jungle-covered area, which had once been a centre of flourishing civilisation, was to be found the answer to this demand for food and agricultural land.

Active reclamation of the dry zone, however, began about 25 years ago. The progress of irrigation development, which consisted mainly in the restoration of ancient irrigation schemes, has been very rapid, particularly in the last fifteen years, but it is estimated, however, that even with the maximum development of our irrigation potentialities an extent of about 2,650,000 acres of Crown Land would still remain unirrigable (1).

The major objectives of agricultural research projects in the dry zone would, therefore, be concerned with the development of economic systems of farming or other systems of land use on these unirrigable lands. At first sight the problem seemed simple enough (2, 3, 4, 5). The approach to agricultural improvement was to be by the intensification of rice production on the irrigable lands by the use of new varieties and improved cultural pratices, and by the replacement of the *chenas* by modern methods of rotational farming. While rice yields have been raised by improved management, actual experience on the uplands did not bear out the initial hope. The causes for the apparent failure of these methods had to be investigated afresh. It became necessary to know more about climate and soil factors and to understand their effects on agricultural practices. It also became desirable to study indigenous agricultural practices more closely to seek explanations for and to isolate the basic principles underlying these practices. This paper reviews the available information on the dry zone and attempts to trace the development of agriculture in the dry zone and isolate some of the principles underlying traditional practices so as to indicate some of the problems of development and outline future lines of research.

The Dry Zone Environment. It has been usual to divide Ceylon into broad natural regions based largely on the distribution of rainfall. The wet zone, bounded approximately by the Deduru Oya on the North, the Walawe Ganga on the South, the sea on the West and the eastern foothills of the hill country on the East, has a mean rainfall of over 75 inches. Lands outside this area constitute the dry zone, where the mean rainfall is under 75 inches a year and where there is a pronounced drought during the South-West monsoon from May to August. On this basis the dry zone covers nearly three quarters of the island (1).

The natural vegetation over a greater part of the dry zone is a mixed evergreen forest which appears to be seral and secondary in character. The structure of the forests is relatively simple. The trees are mainly micro and mesophylls of both evergreen and deciduous species. The shrub layer up to 10 feet is generally light, the field layer is grassy. There is normally very little leaf litter, Climbers, including large lianes, are frequent and add considerably to the cover given by the dominant over-wood (6).

Life in the dry zone has always been difficult. To quote from Ivers Manual of the N. C. P.—

" It may be broadly stated that without artificial irrigation and storage of water human existence in the North-Central Province would be impossible " (7). The lack of perennial rivers (with a few exceptions), the absence of subterranean water supplies, a rainfall distribution that is nearly ineffective for eight months in the year (8), a markedly undulating topography that makes irrigation difficult, are factors that aggravate the shortage of water during the dry season from May to September.

Soils are relatively low in available nutrients, organic matter and range of available water. Fertility is easily lost under exposure, methods of clean cultivation and poor management. Taken generally soil moisture conditions are not favourable for the cultivation of annual and perennial crops throughout the year.

In an environment with such a combination of adverse physical characteristics, in which water supply is a limiting factor to the extension of human settlement and agriculture, the problems of land utilisation and management are unique and complex. Yet it is in this same environment that the ancient Sinhalese civilisations reached their highest state of development. It is certain, therefore, that some lessons for the future can be learnt from traditional practices for the development of the dry zone agriculturally.

The Tank Village. The early settlers from India introduced into Ceylon the art of irrigated rice cultivation and a knowledge of the construction of channel and ancient irrigation systems originally developed in the Euphrates. In an environment widely dfferent from that of their homeland they created an unique and extensive system of irrigation, which, while fundamentally a development from the tank village was characterised by the high tank bund that was peculiar to Ceylon at that time (9).

The basic feature of this system was the construction of reservoirs by damming of river tributaries and streams and linking of the larger reservoirs, through anicuts and channels, with perennial sources of water in wet zone. The larger reservoirs in turn augmented the supply of water in the smaller reservoirs. Each reservoir (tank) became the centre of one or more village settlements (the tank village). The Nalanda-Kalawewa-Yoda Ela system serves as an excellent example of this type of construction (10).

The feudal organisation that developed in Ceylon had the conventional forms (11) and was characterised by a high degree of centralised control under a single king, which was both the cause and the result of the highly-developed and inter-linked system of irrigation. Piecing together the available evidence it would appear, however, that the bulk of the peasants lived in the tank village settlements and practised a system of agriculture using techniques very much the same as in use today in the remoter areas in the dry zone.* Increase in production was obtained by an increase in the acreage, that is by an increase in the number of tank villages and by a stabilisation of the water supply for rice cultivation in these villages by links with assured supplies of water. It would be safe to conclude that the tank village settlement was then the basic settlement pattern of the dry zone as it is today.

The dry zone of Ceylon is made up of several river valleys. Within each river valley the minor valleys, though relatively shallow and narrow, are well-defined so as to give a gentle undulating appearance. A topography of this type is ideal for the construction of tanks. Reference to the inch to a mile topographical maps of the dry zone show that there was a similar agricultural development within each river valley in the ancient days. Dams were constructed at intervals on streams and tributaries resulting in a series of reservoirs (tanks) from the main watershed down each stream and tributary to the points at which they joined the main river.

The Physical Basis for the Traditional Tank Village Settlement. Most of the dry zone rivers, with the exception of the Ambanganga, Walawe and Galoya

* For instance Knox, who paid considerable attention to detail, makes no reference to the practice of transplanting rice. It was Governor North who introduced transplanting into Ceylon from India.

do not have their catchments in the wet zone proper and being dependent on the dry zone rainfall are seasonal in flow. Studies on the run-off and the behaviour of ground water at Maha Illuppallama have indicated that the rainfall during the period from February to September makes, in most years, little or no contribution to ground water for domestic or irrigation purposes during a greater part of the year.

The shortage of water supply during the dry season is further aggravated by the fact that there are no reliable supplies of under ground water in the dry zone. The bedrock is made up of non-water bearing impermeable crystalline gneisses and metamorphic deposits of the Khondalite series. While the jointed and fissured crystalline limestones and quartizites do supply some water, by and large the sources of water are limited and cannot be depended on for irrigation or extensive domestic use.

At the same time the water storage capacities of the sub-soils are very low. Rock outcrops occur all over the dry zone particularly along the low divides. Borings carried out by the Irrigation Department in various parts of the dry zone have indicated that the bed rock lies relatively close to the soil surface. At Maha Illuppallama, for instance, the average depth of sub-soil and decomposing rock above the bed rock was found to be about 18 feet ; the maximum depth 42 feet. Studies on the behaviour of ground water, further show that the ground water level rises during the rains and disappears altogether during the dry seasons unless held up artificially by seepage from a tank or irrigation channel.

Air and soil temperatures are high during the dry season. Strong winds blow during the months May to August. Evaporation rates from a free water surface during the dry season amount 0.3 to 0.4 of an inch per day.

All these factors tend to intensify the conditions of drought and contribute to make the shortage of water for domestic purposes and irrigation very acute during the dry season. The conservation of water in the dry season is therefore essential. During the wet season from October to January on the other hand rainfall consists mainly of heavy storms of short duration. The run-off from the jungle covered uplands is considerable and the flow in streams and rivers great. There is always a liability to flooding in the lower reaches of the rivers.

It is clear, therefore, that the basic principles underlying the ancient systems of the utilization of water resources are sound. It is also clear that the tank system is well adapted to the environment of the dry zone. It is thus evident that in areas of the dry zone which cannot be brought under the command of major irrigation schemes, the tank village settlement pattern must remain the basic settlement pattern.

The Decline of Early Agriculture. From the sixth century onwards there was a gradual deterioration in the irrigation works as a result of a decrease in manpower in the face of constant foreign invasions and internal disensions and, probably, increasing outbreaks of disease, except for a short period between 1000 and 1200 AD. After the Sinhalese abandoned the dry zone in 1200 AD a complete collapse set in ; the jungle returned and spared only traces of the early civilisation. All that

remained at the time of the arrival of the British were the smaller scattered tank villages in which the peasants lived just above starvation level.

A study of tropical agriculture reveals that the cultivation of irrigated wet land rice is by far the best means of producing carbohydrates (12). It ensures good yields, avoids the use of a fallow, prevents soil erosion and ensures the future. Ancient civilisations founded on the cultivation of irrigated rice have remained stable, supported large populations and survived for thousands of years, for example the Indian, Chinese, Indonesian and Indo-China civilisations. On the other hand all civilisations founded on upland agriculture involving systems of shifting cultivations have long since vanished, noted among these being the Maya civilisation of South America, the Khmere civilisation in Cambodia and the Pagan Dynasty of Central Burma. The Anuradhapura civilisation is one of the few founded on the cultivation of irrigated rice that has vanished. This is partly due to the fact that it did not develop on the alluvial plains of big perennial rivers as did the other civilisations of Asia and was thus greatly dependent for its survival on the efficiency of its irrigation systems. Disruption of any kind would cause a breakdown in the entire agriculture and disruption there was of the worst kind in the constant foreign invasions. Further, shifting cultivation (*chena*) formed an integral part of the agricultural system and in this respect the Anuradhapura civilisation was intermediate between the purely rice-growing Asian civilisations and the upland civilisation of tropical Africa and Asia. Stockdale (13) suggests that excessive chena cultivation may have been one of the causes of the decline of the Anuradhapura civilisation. There is no clear evidence in support of this view except that the seral and secondary character of the natural vegetation is probably an indication of widespread chena cultivation.

Traditional System of Land Use. A characteristic system of land use is common to a greater part of the dry zone villages. The centre of the dry zone village is the tank ; houses are grouped on one or both sides of the tank on relatively high ground beside or below the tank bund, an area referred to as the *gangoda* on which drought susceptible fruit and tree crops are grown, and in addition wells for drinking water are sunk. Rice is continuously cultivated in the valley floor under irrigation from the tank. Both, upland rice on the unirrigable lower slopes and dry crops on the unirrigable upper slopes of the valley are grown under a system of chena cultivation. This threefold system of land use namely, *gangoda, chena, wel-yaya* (rice) has been described by several writers (14) and will be considered here in detail as it exists today, as it can be safely assured that this system is a survival of ancient practices.

The Irrigable Lowlands—" Wel-yaya ". Rice is sown broadcast. Preparatory tillage is with the wooden village plough. Hardly any weeding and no manuring is done. 4-4½ months varieties are sown in the *maha* season (October to March) and 2½ months-3 months varieties in the *yala* (May to August). If the *maha* rains are late a *maha* 3 months crop (December to March) or a *meda* crop (February-March to July) is taken. The fallow paddy fields form the grazing land for the village cattle.

The Village Area.—"Gangoda". This constitutes the area beside or below the tank bund. The main crops grown on the *gangoda* are citrus, limes, jak (*Artocarpus itegrifolia*), pepper (*Piper nigrum*), mango, plantains, papaw, coconut, arecanut, breadfruit * and the betel leaf vine (*Piper betle*), yams of various kinds, cassava (*Manihot utilissima*) and snakegourd (*Trichosanthes anguina*). Plants are grown in a disorderly manner and are not regularly cultivated or looked after.

The Unirrigable Uplands—"Chena"—(i) *The lower slopes—"Wi-hena"*. Here upland rice is sown under the *chena* system. Maize, kurakkan, cowpea and other dry crops are planted on the mounds and anthills in this land class. While varieties of rice exist in the dry zone which are distinguished as upland varieties, these same varieties are also sown in the irrigated lowland fields.

(ii) *The upper slopes—"Goda-hena"*

A. *Supplementary Cereals and Millets*

(*a*) Early sown (September, early October). Kurakkan (*Eleusina Coracana*), Tanahal (*Setaria italica*), Maize, Cumbu (*Pennisetum tpyhodeum*). Maize, Cumbu and Sorghum play a more important part in the Tamil and Muslim areas.
(Upland rice in the low water-logged spots).

(*b*) Late sown (November) Meneri (*Panicum miliaceum*) in case of failure of the above crops or on the bare patches of land left on the *chena*.

B. *Complementary Crops*

Pulses

(*a*) Early sown (September, early October), Kollu (*Dolichos biflorus*) for seed, Bumé, Polon-mé and Mekaral (*Vigna sp*), Avare (*Canavalia ensiformis*), and Dambala (*Dolichos lab lab*) for seed and as a green vegetable.

(*b*) Late sown (November—December). Mung (*Paseolus aureus*), Undu (*Phaseulus munigo*) in case of failure of the above or on the bare patches of land left on the chena.

Fibre Crops

(*a*) Early sown (September—October). Cotton, short staple varieties that are harvested in May, June, July, Ambul (*Hibiscus sabdorifa*).

Oil Seeds

(*a*) *Yala chenas*. Sown March-April—Gingelly. (*Sessamum indicum*)

Spices

(*a*) Early sown. Mustard (*Brassica juncea*), Chilli (*Capsicum annuum*).

Vegetables

(*a*) Early sown. Wattaka (*Cucurbita maxima*), Kekiri (*Cucumis pubescens*), Puhul (*Benincasa cerifera*), Bandakka (*Hibiscus esculantus*), Batu (*Solanum*

* Coconut, Arecanut, and Breadfruit were introduced into the Dryzone after 1850 A.D. Pepper ceased to be an useful crop in the dryzone after the introduction of Chilli during the Portuguese period in 1600 AD.

melongena), Karawila (*Momordica charantia*), and Watakolu (*Luffa acistangula*).

Other Crops

(*a*) Early sown. Landesi (*Amaranthus paniculatus*) and Asamodagan used as a medicine.

Kurakkan, Tanahal, Kollu, Bumé, Cotton, Mustard, Chilli, Brinjal and Aramodagan are sown broadcast mixed together over the whole chena with the first rains in September-October. Every chena does not always contain all these crops but it is usual to have a large number of these crops.

Maize, sometimes Bumé, Me karal, Avara, Dambala, Gourds, and Vegetables are planted together on the anthills and high spots and mounds on the chena. The creepers are allowed to climb up the maize or more often up stumps and tree trunks left after burning. The gourds are left to creep along the ground up the fences that are made round each chena block, up tree trunks and stumps. Ambul (*Hibiscus sabdarifa*) is planted along fences and also along boundaries between individual chena plots.

Meneri, Greengram and Blackgram are sown broadcast either pure or mixed later in the season, that is in November, on the bare patches on the chena and where the early sown crops have failed.

Gingelly is sown in *yala* either in newly-cleared chenas or on the *maha chena* itself after a light hoeing to clear away weeds.

Forest is cut during the dry season in June, July, burnt in August or early September and crops sown broadcast or dibbled as given above with the second rain that falls after the 10-15th of September, that is after the cultivator is sure that the *maha* rains have begun. The time of arrival of the "sowing rains" is uncertain and the sowing season may extend even up till the 3rd week of October. On chenas that have been burnt early and where there is a long delay before sowing the land is given a light hoeing to clear away weeds. The harvesting season for most chena crops is January and February, while the cotton and chilli are harvested by about the middle of July.

A *chena* is usually cultivated for one year, sometimes two and the land is then abandoned for 10-15 years depending on the availability of jungle land in the vicinity. Heavy jungle is preferred for *maha* crops and light jungle for gingelly, if the jungle cleared is specially for gingelly.

Animals. Buffaloes are kept in each village as draught animals for the rice fields ; these animals are not looked after but are turned loose to fend for themselves until the next ploughing season. Buffalo curd and ghee were more extensively used in the past. Neat cattle are maintained for use as cart bulls and in the past for supply of cowghee which was widely used before the use of coconut oil became popular*. The fallow rice fields, tank bed and abandoned *chenas* form the grazing grounds of the village cattle. The habit of drinking milk and the care of animals, cows in particular does not appear to have developed as it did in South India. Cattle however serve some purpose as the villagers often tide over difficult times by selling animals to the butcher. This is not a general practice and is resorted to in times of extreme difficulty.

*Coconut though recorded in the 1st century B. C. in Ceylon does not appear to have been grown in the *gangoda* until about 75 years ago.—Ferguson.

Fish. During the dry season the fish in the village tanks are caught and divided among the rice shareholders in the same ratio as the holdings of rice lands.

The Scientific Basis for Traditional Systems of Land Use. It is evident that each village is a self-sufficient unit though at a subsistence level. It is also evident that the system of land utilisation developed in each village is based on a simple system of land classification.

Recent studies at the Research Station, Maha Illuppallama on ground water behaviour and on soil types are throwing light on the fundamental basis for this pattern of land use. Attention was drawn earlier in this paper to the fact that land in the dry zone is undulating and is made up of well-defined minor valleys. The distance from crest to floor of each minor vally is rarely more than one mile which means that there is relatively no flat land in the dry zone. Slopes on the average are about 3-4 per cent. while slopes over 10 per cent. are rare. The effect of topography on soil formation will therefore become important. It was also pointed out that the bed rock, which is impermeable crystalline rock, lies relatively close to the soil surface. Studies on ground water since 1951 have also revealed that ground water behaviour is a vital factor in soil formation and in determining land usage (15).

Ground Water Behaviour. During the year there is a regular rise and fall in ground water level during the wet and dry seasons respectively. The height to which the ground water level rises is any year is dependent on the intensity of the *maha* rains (15).

Valley Floor (Usually Irrigable Lowlands). During the *maha* rains from September to January the ground water level rises to the surface and remains at or near the surface until about March. There is then a gradual fall during the course of the year until the next *maha* rains. In the absence of a tank in the vicinity or where the tanks dry up, the water level falls more rapidly often to disappear completely in very dry years. This land is water-logged during a great part of the year and is best suited for the cultivation of rice. The soil colour is grey to a bluish-grey (glei). Traditional use for this class of land is irrigated rice.

Unirrigable Lower Slopes. The gound water level rises to the surface during the *maha* rains and falls gradually during the dry season to disappear altogether by about August-September on land that is not in the vicinity of a tank or irrigation cannel. This class of land is thus water-logged during the *maha* season and is not suitable during this season for the cultivation of dry crops. Drainage of these land proves difficult as these lands are adjacent to tanks or irrigated rice fields. The soil colour is grey-brown to grey. The traditional use for this class is upland *chena* rice, the *wi-hena*.

Middle Slopes. Here the ground water level rises to within 1 to 3 feet of the surface during the *maha* rains and falls rapidly during the dry season to disappear altogether about July or August. This land is best suited for dry crops but is in need of some form of drainage during the *maha*. The soil colour is brown. The traditional use for this class is *chena* cultivation with dry crops, the *Goda-hena*.

Upper Slopes and Watershed. Here there is a rise in ground water level only in very wet years, when the level rises to within 2 to 6 feet of the surface. There is a rapid fall in ground water level

during the dry season, disappearing completely about *maha*. This land is best suited for dry crops. The soil colour is red brown to dark reddish brown. Traditinal land use is *chena* cultivation with dry crops, the *Goda-hena*.

Land in Vicinity of the Tank. Here the ground water level remains more or less constant throughout the year, the ground water level fluctuating with the water level in the tank. Soil moisture conditions here are more favourable for the growth of moisture-loving, drought-susceptible tree crops. Traditional use for this land class is for perennial tree crops.

Soil Studies. A catenary sequence of soils ranging from typical non-lateritised red earths to hydromorphic variants of the red earths are readily identifiable in the fields surveys. This could be accepted as the basis of future classification in this area. Three main members of the catenary series are distinguishable, they are (16)—

(*a*) Red to brown soil types, well-drained, highly aggregated with blocky structures. Location—water shed and upper slopes.

(*b*) Brown to grey brown soil types, poorly drained during a part of the *maha* season, moderately aggregated, with a fair structure. Location—middle slopes.

(*c*) Grey to glei soil types, poorly drained, poorly aggregated weak structure. Location—lower slopes and bottom lands.

In terms of land use, therefore, specific land capability classes occur in regular sequence from the crest to the floor in each of the primary catchment (drainage) basin within minor valleys. Since these valleys are usually narrow these land classes occur within short distances.

A tentative scheme of land classification is suggested as follows :—

Class I Water-logged bottom lands

Class II Relatively well drained land influenced by seepage from tanks and channels

Class III Intermittently water-logged lands—lower slopes

Class IV Better drained lands—middle slopes

Class V Well drained lands—upper slopes

Class VI Water shed, rocky outcrops and steep lands

On the results of the research work done so far it is evident that the dry zone peasants through long years of experience developed a simple form of land capability classification. This brings home the point that there has been a conscious awareness of land characteristics which is normally associated with a higher stage of agricultural development than that of nomadic shifting cultivation. Any further development did not probably occur because under low population pressures fertility could easily be maintained by the use of a forest fallow.

Agricultural Organization. The dry zone village of the past, that is before the introduction of a money economy, constituted a well-defined natural unit, agriculturally, socially, and physically. Each village was self-sufficient within the limits imposed by the need for an inter-linked system of irrigation, and exhibited a high degree of social organization. The unity of each village was achieved partly by the fact that each

village was socially homogenous, partly by the application and enforcement of rigid laws and social customs, and partly by the need for joint effort for survival in such an exacting environment. The maintenance of village irrigation works, rice cultivation and the clearing of jungles for chena cultivation required joint effort.

In the physical sense too the area occupied by each village was clearly defined.* The demarcation appears to have been on a watershed basis. The working rule appears to have been that the immediate catchment area of any village tank, the forest lands from which water drained into the rice fields below the tank, the tank itself and the rice fields belonged to the village. The boundary between villages was thus the *Verala* or watershed. In many places the ancient boundaries between villages are still traceable. Each village, therefore, constituted a natural and easily-definable physical unit and had control over all the lands vital for its existence. The forest lands within the village boundaries were regularly felled for chena cultivation. These forest lands unfortunately became Crown property (17), and while the villagers were given the right to *chena* these forests, the physical unity of the village was broken and the idea of a village as a naturally defined unit was lost.

Agriculturally also there was a great deal of co-operation in the villages. This is evinced in the way the rice lands are demarcated and worked. The rice tract (*Wel-yaya*) was usually divided into three sections parallel to the tank bund the section closest to the tank, the "*Mulpotha*" the middle section, the "*Herana-potha*" and section furthest from the tank, the "*Kottakaduwa*". Each shareholder had a holding in each section in the form of a strip that ran across the floor of the valley and parallel to the tank bund. It was the duty of each shareholder to maintain that section of the irrigation channel that ran across his holding. During the *yala* season (April-August) where there is insufficient water in the tank for a full cultivation, restricted cultivation is resorted to on that section of the tract closest to or most easily irrigated from the tank. The *Betme* extent cultivated is dependent on the amount of water in the tank and in any year is divided among the shareholders of the village in the same ratio as their individual holdings to the total extent in the tract. The portions so demarcated are worked individually.

The *gangoda* was communally owned and the produce of the tree crops shared. *Chena* lands belonged to the whole village and every paddy shareholder had a right to a section of *chena* land each year, with the sanction, at the beginning of each season, of the village *Gamarala*. The *chena* lands of all the shareholders in a village were usually grouped together and a fresh block of land was cleared every year until finally the original block was cleared again after a lapse of anything from 10 to 15 years.

Here the early Sinhalese anticipated in a simple form the "corridor system" that has been developed in the Belgian Congo for systematising methods of shifting cultivation. The separation of each block of communal *chena* land into individual holdings during the *chena* season was done by marking a series of radial lines from some central point. Each shareholder worked a single slice.

*According to the *Mahavamsa* the demarcation of the country into villages appears to have been done as early as 437 B.C. in the reign of king Pandukabaya.

This system made allowances for variation in soil and tended to equalise the damage from wild animals at the perimeter.

Each peasant thus had a holding in the rice lands, the *chena* lands and a share in the gangoda produce. He depended on all three classes of land for his existence. In villages where the tank is not linked with an assured supply of water, rice is liable to fail in years of poor rainfall. In these years, however, the *chena* crops are good. In years of heavy rainfall the reverse occurs. The inclusion of both *chena* crops and irrigated rice in a single system is an insurance against adverse seasons.

Basic Features of Traditional Dry Zone Agricultural Systems. It is apparent from the foregoing considerations that the dry zone village had developed to the same level as any village organisation as for example in rural England or Europe in a subsistence economy in feudal times. The basic differences in land use, crops and fertility maintenance technique are the result of differences in climate and soil types. For hundreds of years its development was arrested. If the growth of dry zone agriculture is to be continuous and stable it must develop on the foundations laid throughout centuries of experience. It would appear that the basic principles on which the traditional agricultural systems were founded are :—

(i) The maximum conservation and utilisation of rain water within each river valley.

(ii) The utilisation of water resources from the wetter regions of the country.

(iii) The land usage according to soil type and drainage conditions—each soil sub-type recognised by recent research was used as a definite capability class.

(iv) The utilisation of all lands and the inclusion of irrigated rice and uplands crops in a single integrated system.

(v) The creation artificially of soil moisture conditions favourable for the growth of drought-susceptible perennial crops.

The " techniques " of fertility maintenance used by the peasants of the dry zone, the " grazed fallow " on the rice fields and the " forest fallow " on the uplands, are techniques that are characteristic of those developed in a subsistence economy. The use of a " forest fallow " in particular is characteristic of the semi-humid and humid tropics. If population densities remain low, land can be maintained indefinitely by these methods at the natural productive level of the particular area. Any changes to a higher economy, which is usually followed by an increase in population density must necessarily mean a change in the fertility maintenance techniques if the new demand for production is to be met and the lands prevented from degradation. The problems involved in this transformation particularly in relation to the uplands will be discussed later.

It is clear that the basic principles of land use in ancient Ceylon were sound and are in accordance with modern land

utilisation principles. In the transformation of the village economy to a more productive economy care should be taken to see that the principles on which the traditional system is found are not overlooked but are used as a basis for future development. This would mean in practice the intensification of agriculture within the existing pattern by the use of modern techniques adapted to the dry zone environment in place of the older techniques.

2. Review of the Work at the Maha Illuppallama Dry Zone Research Station.

The official attitude towards *chena* cultivation in the Dutch and early British periods was one of forest protection. *Chena* cultivation was considered a primitive, wasteful practice highly destructive of forests. Several attempts were made to prohibit *chena* cultivation but the practice persisted and even increased. Through the years it became evident that *chena* cultivation formed an integral part of village agriculture and that the pressure of chena cultivation could only be reduced by the provision of irrigation facilities. The official attitude softened and *chena* cultivation was allowed on permits obtainable from the Government Agent of the District. The extents allowed to individuals was strictly limited and the areas available for *chena* in each village demarcated. In this way protection was given to a section of the forest lands.

In 1926 Mr. F. A. Stockdale, then Director of Agriculture after a visit to India saw no reason why the *chena* lands of the dry zone could not be cultivated permanently with annual crops using crop rotation, manuring and implemental tillage (the plough), as was done in South India (18). Initial experiments on small plots were carried out at Anuradhapura, Vavuniya, and Tissamaharama and in 1936, Mr. E. Rodrigo, Director of Agriculture started the first "dry farming" settlement scheme at Kurundankulama to determine if a family could make a living from about 16 acres of unirrigable land (19). By about 1949, however, it became apparent that these initial hopes were not being entirely borne out and there was need for further investigation. Accordingly the Dry Land Farming Scheme was started at Maha Illuppallama in 1950. In 1952-53 the Government of the Dominion of the New Zealand very generously made a substantial financial gift under the Colombo Plan Technical Cooperation Scheme to meet the capital cost of setting up a fully equipped research station for the dry zone at Maha Illuppallama. In this paper the work done in the last few years is reviewed and some of the ideas and concepts that have developed are stated.

The experiments between 1926 and 1936 were carried out on limited blocks of land over a short period of years and on small, established experiment stations. While the results of these experiments indicated clearly that satisfactory yields could be obtained with annual crops, other problems associated with the continuous cultivation of large blocks of land did not become immediately apparent. It was inevitable therefore that certain assumptions had to be made in the layout of fields and location of homesteads when the Dry

Farming Scheme at Kurundankulama was established. These are :

(i) That there are no wide variations in land and soil type and that unirrigable lands could be divided into relatively uniform allotments as is possible over large stretches of South India.

(ii) That crops such as citrus, papaw, plantains, coconut, etc. could be grown on any homestead irrespective of its location.

(iii) That water supply for domestic and stock purposes was freely available from wells, as it is in the wet zone.*

(iv) That conventional dry land farming methods developed in South India and elsewhere in the world would be applicable in the dry zone of Ceylon.

Subsequent experience in the dry zone began to make it clear that these assumptions were not quite correct. In addition the following general conclusions could be drawn from the experience gained up to 1950 :

(i) There was a rapid decline in fertility on the unirrigable lands and there is need for a rest period of 3-4 years after a period of 3-4 years' cultivation. (1).

(ii) The low-lying unirrigable lands became water-logged in *maha*. There was need for a change in the recommended system of land use. The cultivation of rice on the unirrigable low lands was suggested (20).

(iii) The cultivation of *yala* crops was uneconomic in most years with the possible exception of *Sessamum indicum* (Gingelly).

(iv) The control of weeds presented an almost insurmountable problem.

Rainfall Characteristics. Rainfall (distribution and intensity) is the most important factor determining agricultural production. Taken together with the other physical factors of the dry zone it results in the formation of an environmental complex markedly different from that of the dry areas of India, Burma and Africa. It would be expected, therefore, that the agricultural practices developed in the latter countries would not be entirely applicable here. It has already been shown in the first part of this report that the assumptions relating to the uniformity of land and the existence of domestic water supply have not been correct. On the other hand it has been shown that the indigenous systems of settlement and land use are better adapted to the dry zone environment.

In Table I is given a summary of the rainfall for Anuradhapura for 1906-1945 which serves as an example of rainfall distribution in the Northern Dry Zone. Some idea of the intensity of individual storms can also be obtained from Table I.

*Kurundankulama was fortunate in that its wells derived their water from the adjoining Nuwara Wewa.

Table I—Monthly Rainfall, Anuradhapura

Nature of Rainfall	*Month*	*Rainfall Medium 1906–45 in inches*	*No. Wet Days*	*Cropping Seasons*	*Total Rainfall in inches in each Croppings Seasons*
Inter-Monsoon	September	2·4	5		
	October	9·0	16		
		Wet Season		MAHA	33·3
North-East Monsoon	November	10·1	18		
	December	7·2	16		
	January	3·4	9		
	February	1·2	5		
Inter Monsoon Season	March	3·1	2		
	April Dry Season	5·8	12		
	May	2·2	7		
				YALA	12·5
South-West Monsoon	June	0·6	4		
	July	0·2	3		
	August	0·7	6		

Storms of one inch in 8-25 minutes, two inches in 30-40 minutes, three inches in 100 minutes and 4 inches in 100-120 minutes have been recorded at Maha Illuppallama. It is not infrequent to have storms of 2-5 inches in an afternoon and evening.

In terms of water supply there are thus two clear periods in the year, one a wet season from September/October to January when rainfall is relatively reliable and effective and is made up of many storms of short duration ; and the other a dry season, from February to September, when rainfall is unreliable, highly variable and ineffective. It is these qualities of intensity and distribution of rainfall acting in relation to factors of soil type, topography and depth of the regolith that create problems different from the other 'dry farming' areas of the tropics.

Soil Moisture and Crop Growth. From the results at Maha Illuppallama and from experience gained elsewhere in the dry zone the following general conclusions could be drawn with relation to crop growth and performance :—

1. Cultivated perennial crops such as coconut, citrus, jak, breadfruit, papaw and plantains perform poorly and often die in severe droughts on the unirrigable land particularly on the upper and middle slopes. The damage is intensified if there are no shade trees and if the plots are clean weeded. But mango, cashew-nut, murunga and palmyrah grow well and yield satisfactorily.

2. It is difficult to establish and grow successfully a long-duration crop or cover during the dry season, but on the other hand if these crops are sown early in the wet season or are well-established before the commencement of the dry season then they withstand

drought qquite satisfactorily. Velvet Bean, *Dolichos Lab Lab, Mirosa invisa, Alysicarpus vaginalis, Stylosanthes gracilis*, pigeon pea, castor, *Bracharia bryzantha*, and Napier Grass are examples. However, in very dry years and when, as in 1955/56, the wet season rains failed the covers died out altogether. Pigeon pea and castor and to a lesser extent *Bracharia bryzantha* and Napier proved to be drought resistant.

Depression in yield or failure of annual crops occurs more frequently in very wet years than in dry years. Complete failure due to drought in the wet season is rare if the sowing has been done early.

A knowledge of rainfall and soil moisture characteristics throws light on these observations. The soils have a narrow range of available moisture, for example the red earths have at wilting point a water content of 8 per cent., at field capacity a water content of 17 per cent. and at saturation a water content of 25 per cent. The available range of moisture is thus only 9 per cent. When drying out, the soils lose over 85 per cent. of their available moisture at tensions as low as one atmosphere (21).

The soils of the dry zone are for the most part derived from the Khondalite and Vijayan series of the Archean complex of crystalline rocks. The acid gneiss is very resistant to the usual weathering processes compared to the less acidic and the basic rocks which give rise to deeper soils on weathering under the same conditions. These factors are mostly responsible for the shallow nature of the greater part of these soils.

It is clear that the dry zone soils have no great storage capacity nor can they continue to supply moisture for the growth of shallow rooted crops without frequent replenishment by rainfall. Those deep rooted crops that are established before the rains cease, continue to draw there moisture from the deeper layers of the soil and from the water table itself.

During the wet season, in spite of the good internal drainage of the profiles, the impervious nature of the underlying gneiss prevents vertical drainage and the ground water level therefore builds up. As the heavy rains continue the whole profile becomes wet and in heavy storms precipitation greatly exceeds infiltration. There is then a tendency for water logging at the soil surface.

From the foregoing the following general conclusions can be drawn :—

(i) Any long duration crop or tree should be established only in the *maha* season.

(ii) Drought susceptible, shallow rooted perennial crops should not be grown on the uplands without supplementing irrigation either direct or by seepage.

(iii) Some provision for surface drainage is necessary on the uplands particularly in very wet years.

(iv) Some system for disposal of surplus storm water is necessary.

(v) There is need for the study of effect of shade on soil moisture conservation and in reducing the rate of drying.

Disposal of Surplus Storm Water. The surface of the land from crest to floor of each minor valley is broken up into small primary catchment (drainage) basins. For the efficient control and disposal of storm water it is essential that each individual basin be treated as the smallest unit of land management. No detailed surveys have been made but it would appear from experience on the lands that have already been cleared that these basins vary between 30 and 200 acres in extent.

Within each catchment basin the use of a system of graded terraces discharging storm waters at non-erosive velocities into the natural drainage line—cleared, straightened and converted into a grassed waterway—has been found most effective in the control of gully erosion. At first the broad-base terrace bunds and channels were cultivated but the bunds tended to disappear in the heavy rains. However, for the present, narrower terrace bunds and channels are being used and are either left under natural grass (this practice carries a hazard in that the fields are re-infected each year by weed seeds from the bunds) or are put under a fodder or pasture grass. Once soil conserving cultural practices have been developed it may become possible to cultivate both bund and cannel.

Attempts to use groundnut as the close spaced crop in a system of strip-cropping did not meet with much success as the greater part of the erosion occured before the crop was establised. It would appear that the erosive rains are concentrated too near the beginning of the season to make the use of strip-cropping with annual crops a success. The use of perennial crops, such as grass or perennial legume as the protective strip, offers some possibilities. Due to the higher rainfall of the wet season in the dry zone it would become necessary in any case to provide for the disposal of water through terrace channels even at wider intervals.

Soil Erosion and Weed Control. More serious however is the damage or splash erosion that is caused by the impact of rain drops on a bare soil. The damage while not apparent is far more insidious as it results in the displacement of the vital clay fraction to lower depths of the profile together with its removal through surface run-off. Several years of splash erosion would give rise to a condition of soil where a poorly areated dense horizon underlies sandy surface soil.

In Ceylon under traditional systems of shifting cultivation no implements are used other than the hoe (mammoty). Thrash is removed by burning. No traditional implements are available and the tillage implements were, therefore, limited to the imported mould plough, disc plough and disc harrow. The mould board plough was discarded as it was found unsuitable on newly-cleared land, the damage to the plough and wear on the plough shares in a soil with a high quartz content was excessive. Tillage practices were thus developed around the disc plough.

Weed growth is very rapid and land left fallow for any length of time is soon covered with a heavy growth of weeds.

Deep ploughing to bury as much weed as possible with the disc plough and the repeated use of the harrow had to be resorted to for effective weed control. This left the land clean, bare and exposed to soil erosion. A series of experiments were carried out at Maha Illuppalama between 1951 and 1956 to investigate methods of checking splash erosion and reducing run-off.

Mechanical Methods. In these experiments an attempt was made to retain as much water on the land as possible.

Sub-soiling. Experiments in 1951 and 1952 to determine the value of sub soiling at 2 feet intervals to a depth of 18-20 inches, indicated that in 1950-51 which was a dry year there was a small but appreciable increase in yield of 17 per cent. after sub-soiling. In 1951-52 on the other hand which was a wet year no increases in yield were obtained with the next crop in the rotation which was cotton.

Run-off from the experimental plots was measured manually through small weirs. While the measurements were not very accurate some indications were obtained. (i) At the beginning of the rains there was less run-off from the sub-soiled plots. This difference tended to even out as the season progressed and also in heavy storms. (ii) The surface of the sub-soiled plots tended to remain drier while the untreated plots showed signs of water-logging. In 1951-52 which was wet this difference was not noticeable. (iii) The run-off water from the sub-soiled plots was freer of clay and suspended material from the sub-soiled plots under chilli in 1950-51. The difference was not noticeable under cotton in 1951-52. No information on the vertical movement of clay down the profile was obtained.

Estimates of moisture percentage at depths of 3, 9 and 18 inches indicated that in 1950-51 the sub-soiled plots tended to remain moist and dry out less than control plots particularly at the 9 in. and 18 in. depths. In 1951-52 this difference was not noticeable.

It did not appear that there were any great advantages to be obtained from sub-soiling particularly in view of the high cost of the operation and also with regard to the difficulty of getting the right soil moisture conditions so that the operation could be done well before sowing time. Further experiments were discontinued.

Contour Listing. An experiment was conducted in large plots to study the effect of contour ridges on the yield of crops and on run-off and erosion. Ridging was done with a tractor-drawn lister plough and cotton and chillies in the respective experiments were planted on top of the ridges which were spaced 3 feet apart in the cotton plots and 2 feet apart in the chilli plots. The results are given in Table II.

Table II

Year	Treatment	Crop			
		Chillies		Cotton	
		Mean Yield per acre (Dry pods)	Per Cent. of Control	Mean Yield per acre (Seed Cotton)	Per Cent. of Control
1950–51	Flat, clean cultivated	409	100	300	100
	Contour ridged rows	709	173	601	200
1951–52	Flat, clean cultivated	144	100	316	100
	Contour ridged rows	111	77	256	81
1952–53	Flat, clean cultivated	689	100	336	100
	Contour ridged rows	643	93	275	80
	Flat cultivated in thrash cover	853	124	478	138

Rainfall from September to January

Year	Rainfall inches	No. of Wet Days
1950–51	23·19	57
1951–52	46·72	53
1952–53	15·00	30

In *maha* 1950-51 the contour ridged row treatments gave yields nearly double that of the flat clean-cultivated plots. Rainfall was moderate and well distributed throughout the season, while in *maha* 1951-52 the yields were lower than that of the control. Rainfall was very heavy and water was held up in the furrows and water-logging resulted. In *maha* 1952-53 on the other hand the yields in the ridged row plots were again depressed due to the fact that the ridges dried faster than the control plots.

Yields on the contour ridged row plots tend to fluctuate widely with season. This effect appears to be more pronounced with chilli which is a shallow rooted crop. While there was a marked reduction in the run-off in light storms, with storms of over 2 inches there was only a small or insignificant reduction in the run-off. There was no control over splash erosion which resulted in the clay particles and smaller soil aggregates from the surface of the exposed ridges being washed down the furrows. In addition, in these very heavy storms the damage to the ridged-row land was great. Furrow and basins on the basin-listed land filled up with water which overflowed as the rains continued. Due to irregularities on the surface of the terraces breaches occurred in the tie ridges and main ridges and damage was often quite serious. This system therefore carries a serious hazard. There is a further difficulty, as in the case of sub-soiling, that relatively heavy equipment

is required as the operation has to be done quickly in the short spells before sowing when moisture conditions are satisfactory. In very dry years the operation cannot be done at all as the dry soil becomes too hard for working. In these years contour furrowing has to be done with the " sowing rains " and the season is delayed or lost altogether if the early rains are too heavy to prevent working of the land.

Mixed Cropping Methods. Mixed cropping experiments carried out at Maha Illuppallama were designed primarily with a view to determining the value of mixed crops in controlling erosion in row crops such as cotton, chilli and maize, and not with a view to understanding any fundamental relationships. The results obtained, however, indicate that there is a need for a deeper study of mixed cropping in the wider background of tropical agriculture as a whole and with a view to developing practices that are better adapted to soil, climate and economic conditions.

Cotton and chillies were planted in rows at a spacing of 3 feet apart ; the following crops were sown in rows spaced 1 foot apart between the cotton and chilli rows, green gram, black gram, cowpea, groundnut and jak bean. The experiments were carried out for three years with substantially the same results. In Table III are given the results of the first year 1950-51.

Table III

Treatments	*Crop Yield in Pounds per Acre*					
	Cotton			*Chillie*		
	Yield 1950–51	*Per Cent. Depression*	*Yield of Associated Crop*	*Yield 1950–51*	*Per Cent. Depression*	*Yield of Associated Crop*
	Seed Cotton			*Ripe Pods*		
Main Crop	556	—	—	1,369	—	—
+ Green Gram	458	18	422	262	81	473
+ Black Gram	411	26	229	431	69	332
+ Groundnut	403	28	849	356	74	884
+ Cow Pea	70	97	947	108	92	1,117
Canavalaia ensiformis	65	98	2,019	—	—	—
Significant difference	72	—	—	132	—	—

The associated crops are arranged in Table IV in the order of their effectiveness in checking erosion ; green gram as least effective and *Canavalia* as the most.

The more effective the associated crop is in erosion control the greater its adverse effects on the yield of cotton and chilli. It would appear that with cotton the only association that may be of some value is the combination with groundnut. Chilli does not appear to tolerate another crop growing with it.

The results of an experiment carried out in 1952-53 and 1953-54 with cotton, groundnut and green gram are given below :—

Table IV—Cotton Yields

Cultural Treatments	*1952–53*		*1953–54*	
	Yield per Acre (Pounds)	*Percentage Depression below Control*	*Yield per Acre (Pounds)*	*Percentage Depression below Control*
Cotton alone	303	—	288	—
Cotton and groundnut ..	126	59	117	59
Cotton and green gram ..	169	44	149	48
Significant difference ..	45	—	41	—
Rainfall during growing season (October to March) in inches ..	18·9		40·58	

The percentage depression of cotton yields by the associated crops at different levels of manuring are given in Table V.

Table V—Cotton Yields

	With Groundnut		*With Green Gram*	
	1952–53	*1953–54*	*1952–53*	*1953–54*
No compost	70	69	64	71
Compost at 5 tons/acre ..	54	58	47	49
Compost at 10 tons/acre ..	52	52	24	34

The results given in Table IV indicate that there is a considerable reduction in the cotton yields when the crop is grown mixed with groundnuts or green gram. This experiment was set down only to investigate the effect of mixed cropping on cotton yields and no plots carrying only legumes were included in the experiments. The yields of the legumes do not appear, however, to have been depressed to the same extent as the cotton though they are a little lower than would be normally expected.

The results obtained in the two years are substantially the same, even though the rainfall in 1952-53 was only 16.9 inches as against 40.58 inches in 1953-54, which seems to point to the fact that the competition for moisture is not the chief

factor involved in the competition between crops. Results from Table V appear to indicate the depressing effect of the legumes is reduced at higher manurial levels. This calls for more detailed investigation, indicated from incidental information obtained from a fertiliser experiment set down in *maha* 1955-56 to investigate the effect of different levels of compost and superphosphate on the yields of maize and cowpea grown together in association. The pure cowpea and maize plots were tacked on to the ends of the blocks of the fertiliser experiment and as such the yields from the plots cannot be subjected to a complete statistical analysis along with the rest of the experiment. The results presented in Table VI, however are indicative :—

Table VI

Treatment		*Yield in pounds per Acre*			
		Maize		*Cowpea*	
		Percentage Yield	*Percentage Depression below pure plot*	*Yield*	*Percentage Yield Depression below pure plot*
1. *No fertiliser*	Pure	2,145	—	1,078	—
	Mixed	1,065	50·4	561	48·0
2. *Fertiliser* 5 tons compost 20 lb. P_2O_5 per acre	Pure	2,415	—	968	—
	Mixed	1,680	30·4	522	46·1
3. *Fertiliser* No compost 60 lb. P_2O_5 per acre	Pure	—not included	—	—	—
	Mixed	2,040	—	499	—
Significant difference					

The degree to which the cowpea yields in association with maize are depressed does not appear to be influenced by fertiliser application. While with maize on the other hand the depression in yields in association with cowpea appears to be reduced at higher levels of superphosphate application. There is thus an indication that maize shows a differential response to phosphate, the response to phosphate being greater in the mixed plots. No tests of significance of interactions are possible and these findings will be subjected to a detailed study before any definite conclusions can be drawn.

The above experiments included crops of nearly the same age with nearly similar root systems. The results of a mixed cropping experiment with crops of different ages and root system i.e. pigeon pea and sorghum are given in Table VII.

Table VII

Sorghum Yield at spacings of Pigeon pea	*Yields per Acre (Pounds)*
S_0 36″ × 12″	2,025
S_1 72″ × 12″	3,015
S_2 108″ × 12″	2,985

Pigeon pea yields	*Yield per Acre (pounds)*	*Per cent. of Control*
Pigeon pea alone	778 ..	100
Pigeon pea plus Sorghum	617 ..	79
Significant difference	141 ..	—

No pure sorghum plots were included in the experiment which was designed to test the effect of sorghum on pigeon pea and comparision with a pure crop of sorghum can be made. The sorghum yields however are nearly as high as would be expected from a pure stand. The pigeon pea yields on the other hand show a depression when grown together with sorghum. These results are similar to those obtained elsewhere in the world. The practice of mixed cropping pigeon pea and sorghum offers possibilities. Under normal conditions pigeon pea gives its main yield about six months after planting, that is in *yala*, while sorghum can be harvested in three and a half months, that is the *maha*. It is difficult to establish pigeon pea in the *yala* season and it is sown mixed with sorghum in *maha* it will be possible to take a *maha* crop of sorghum and a *yala* crop of pigeon pea off the same piece of land with only a small reduction in the yield of the pigeon pea.

It became apparent as the experiments progressed that the use of mixed croping either with crops of the same age or of different ages did not very materially reduce the damage from splash erosion if the two crops were sown together at the begining of the season. The most erosive rains occur early in the seasons in the intermonsoon period between September and November and for 3-4 weeks after sowing little protection is afforded the soil from splash erosion. The annual contribution to erosion from this source when considered over a long period of years can be considerable. On *chena* lands, however, cultivated once in 10 to 50 years the contribution from this source of erosion is negligible. Some other form of protection is therefore necessary at least during the initial period or until the crops are established. This can be obtained by one of the components of the mixture being a permanent or semi-permanent protection crop or by the use of thrash mulches to protect the land from splash erosion.

Thrash Mulch Methods. From 1951 experiments were carried out to investigate the value of thrash mulches in

reducing splash erosion and the effect on the yield of crops. The results of an experiment with cotton are given below :—

Table VIII

Cotton Experiments	*Yields of Seed Cotton in pounds per Acre*					
	1952–53	*Per Cent. of Control*	*1953–54*	*Per Cent. of Control*	*1954–55*	*Per Cent. of Control*
Cultural treatments—						
No thrash cover	722	100	418	100	349	100
Thrash cover on surface	891	132	449	107	447	128
Fertiliser treatments—						
No fertiliser	786	100	436	100	349	100
Fertiliser—						
30 lb. Nitrogen 30 lb. P205	779	99	441	104	442	127
Significant difference	125		Not significant			
Rainfall during growing season (October–March) in inches	16·9		40·58			

The results indicate that there is no depression in yield in the thrash covered plots. The plants in these plots, however were less vigourous in the early stages of growth in the last two wet years. Sowing in these experiments was done with the first rains in September and germination occurred in the short dry spell that followed. The young seedlings were established before the next space of heavy rain that commenced in October. Elsewhere on the research station depression in yields was obtained in 1953 and 1954 in the thrash covered fields, when cotton was sown just before the heavy rains in October. The cover in all the velvet bean plots was 3-4 inches thick and it was observed that during the heavy rains the thrash absorbed and held larger quantities of water like a sponge. Ungerminated seeds, germinating seeds and very young seedlings were killed by the excessive moisture and attacked by a fungus. Poor stands thus contributed to the lower yields. Stands could, however, be improved if a lane was cleaned in the cover about 4-6 inches thick and the seeds sown in the middle of the lane. It would appear, that there is an optimum density of cover, sufficient to protect the land from erosion and not too thick to cause unfavourable moisture conditions at the soil surface. Apart from the physical effects depressions in yields resulting from an unfavourable nutrient balance between crop, soil and thrash cover have yet to be investigated. Results from the run-off in the last three years have indicated that erosion can be considerably reduced if land is protected by some form of stubble mulch or thrash cover. It has also been observed that use of cover crops reduces very considerably weed competition in the following cultivated crop.

An account of the difficulty of raising covers in the dry season and due to the fact that land cannot be allowed to remain for one year under an uneconomic cover unless it is for the purpose of soil recuperation, experiments are now in progress to investigate the possibilities of growing a perennial or long duration cover in association with row crops such as maize, cotton, etc. This practice in reality means the development of a system of mixed cropping with crops of different ages in which one component will occupy the field for a number of years while the other short duration component of the association is repeated several times, or in which there is a sequence of crops over the period of years that the long duration component is in the field.

Some of the covers under study are *Alysicarpus vaginalis, Dolichos Lab Lab,* Velvet Bean, *Stylosanthes gracilis, Mimosa invisia* (Thornless strain), *Indigofera endecephela, Indigofera subulata,* perennial strains of wild groundnut and lucerne. Attempts are being made to introduce as large a number of leguminous covers from as many tropical countries as possible.

Weed Control and Tillage. The few tillage experiments that have been carried out in the tropics tend to bear out the general truth of the conclusion drawn from work in England and America. Many more critical experiments are necessary in the tropics before these conclusions can be definitely accepted. They can however be used as a guide to the development of tillage practices in the tropics. The main conclusions are :—

(i) In a well distributed rainfall the main function of tillage is in the control of weeds. Under weed-free conditions the nature, depth and frequency of tillage have no influence on the final yield of crops.

(ii) Under rainfall conditions in which spells of drought occur during the growing season while the principle above appears to hold good in general those tillage practices that result in better moisture conservation give higher yields.

(iii) Almost all tillage practices caused some degree of deterioration in the physical condition of the soil. In soils with relatively unstable structure this deterioration is very rapid, particularly if tillage is done when the soils are too dry or too wet.

Recent work on the dry zone soils indicate that a crumb structure is either totally developed or absent in the soils. The well developed coarse, blocky structure is the morphological type evolved under this climate. Its structural bonds are due largely to the inorganic soils colloids which are irreversible in contrast to the organic matter bonds of the temperate climate which are for the most part reversible. Breakdown of structure is easily caused by the pulverising and grinding action of agricultural implements and extreme caution must be exhibited in the use of the implements because structures once destroyed cannot easily or never be restored. Attention should also be again drawn to the fact that soil moisture held at low tensions is lost very rapidly and the soils are also quickly saturated and become fluid after heavy storms. The period of time during which optimum moisture conditions exist is therefore

very short and chances for destruction by tillage implements are thus very great. During the dry sason the soils dry out and set like rock. Any attempts at tillage with power implements during this period can be disastrous.

In Ceylon the chief tractor drawn implement used on the uplands has been the disc plough, the mould board plough and the disc harrow. If an inverting implement is to be under conditions in which it would do minimum damage to the soil it is necessary that the soil should be at optimum moisture content to a depth at least a little greater than the minimum required for the most efficient working of the implement. This depth is usually form five to seven inches. (i) When a crop is taken in *yala* (March to June) the period available for preparatory tillage for the next *maha* crop (October to February) is between the months July to September. Rainfall during this period is highly variable and is usually so low that optimum conditions for the use of an inverting implement are obtained only in a few years. In order to get land ready for sowing at the end of September or in early October, the disc implement has to be used under conditions too dry for its efficient working. Excessive damage to the soil is the result. If on the other hand preparatory tillage operations are delayed until satisfactory soil moisture conditions prevail the land frequently cannot be got ready in time as the first rains in the *maha* season which are normally used for sowing have to be used for preparatory tillage ; late sowing results or the season is missed altogether. (ii) When no crop is taken in *yala*, ploughing can be done under optimum conditions with the rains in April and May. The land has, however, to be left fallow and exposed for a period of five to six months until the sowing seasons begins at the end of September. During this period there are often small showers of rain that wet the soil to a depth of two inches and are sufficient to cause germination of the weed seeds. Weeds soon cover the plots and two or three life cycles are completed before the sowing season is reached. Use of the disc plough and repeated use of the disc harrows have to be resorted to, more often that not under conditions that are too dry, in order to obtain weed control and to break down the seed bed to a condition suitable for seeding at the correct time.

All these practices while resulting in relatively clean weed free seed beds have caused excessive demage to the soil ; considerable erosion has thus resulted. It would thus appear that the plough, disc plough and disc harrow are not very well adapted to the rainfall and soil conditions of the dry zone.

The use of intercultivation implements for weed control in between row crops also present a series of difficulties. With every operation the soil surface is exposed afresh to rain damage. In very wet years no intercultivation is at all possible and weeds get completely out of control.

During the dry season from May to August relatively strong winds blow across the dry zone. The damage to exposed land particularly if cultivation is attempted during this period can be excessive. Any form of cover or mulch checks this source of erosion.

From the work done so far on erosion and weed control, the following general conclusions can be drawn :—

(i) Some form of continuous protection in the form of a mulch or

a crop is necessary from rains during the wet season and from wind during the dry season. The use of continuous cover on the land also reduces weed competition.

(ii) Inversion tillage implemets are not adapted to the dry zone environment. A serious hazard is introduced in an attempt to control weeds with these implements.

(iii) Tillage operations should be reduced to a minimum. If tillage implements are to be used these should be of a non-inverting type, which leave a maximum of protection stubble on the surface. These implements should also be capable of operating fast while satisfactory moisture conditions for tillage exist.

Experiments are being carried out at Maha Illuppallama to test the value of (i) shallow operated disc tiller in cutting and spreading the stubble or thrash on the soil surface; (ii) sub-surface sweeps, blades and rod-weeders for the control of weeds in the stubble mulch left by the tiller. Seed drills and intercultivators for operating in thrash covered plots have been built at the research station. It is clear that some compromise between the degree of destruction to soil and the degree of weed control cannot be avoided. It would appear, however, that the same reliance cannot be placed on tillage implements for the control of weeds that is placed in the drier and other areas with a milder and better distributed rainfall.

Alternative systems involving the use of cover crops, &c., have to be developed. It has been found that sun hemp (*Crotolaria juncea*) sown at the beginning of the *yala* season gives excellent control over weeds.

Chemical Weed Killers. The use of chemical weedkillers offers the greatest scope for the control of weeds without tillage. Experiments with the use of various formulations of 24D, MCP for the control of weeds in maize, sorghum and minor millets with DNBP for the control of weeds in groundnut, cowpea and other pulses and TCA in the control of pernicious perennial weeds such as *Cynodon dactylon* are in progress.

Time of Sowing. Time of sowing trials have clearly brought out the fact that dry zone is no exception to the general rule that in any system of rain fed arable agriculture time of sowing has a great influence on yields of annual crops. Based on the information obtained so far and also using traditional experience as a guide the following general classification of crops with relation to sowing time has been prepared.

Maha Season

Early sown crops (4 months crops)
Mid September to mid October

After the first rains have wet the soil sufficiently (i) to ensure germination, (ii) to permit a maximum of 3 weeks growth without further rain (for practical purposes if the soil is wet to a depth of 9-12 inches these conditions will be met) the following crops are grown :—

Maize, Gourds, Vegetables, Brinjal, Bandakka, Cotton, Deccan Hemp, Pigeon pea, Castor, Lab Lab, Velvet Bean.

To ensure a satisfactory germination these seeds should be planted to a depth of 1-2 inches. Soaking of the seed overnights before sowing into a wet soil ensures better stands.

Last week of September to third week of October

(i) During the dry spell that follows the first rains and just before or with the second spell of rain kurakkan, mustard, upland rice should be grown. Seeds should be covered lightly to prevent their being exposed by rain and being washed away ; if planted too deep stands are poor.

(ii) With the second spell of rain grow the following-groundnuts kollu (*Dolichos biflorus*), Lab Lab (*Dolichos Lab Lab*), manioc, long duration varieties of sorghum, chilli (transplanted), velvet bean, pigeon pea. Often if the second spell of rain is heavy the sowing of crops under (ii) above may be delayed considerably.

Mid-season sown crops (3½ months to 3 months) crops.
Mid October to end of October

During a dry spell following rain after the middle of October the following can be grown :—

Cowpea, Sorghum (short duration varieties) and Tanahal (*Seteria italica*), Pigeon pea, *Dolichos Lab Lab* and velvet bean.

Late season crops (3-2½ months crops)
Mid to end of November

Green Gram, Black Gram, Meneri and Soya Bean.

Perrenial crops and trees before the end of November

Pasture grasses should be established before mid December if these are to withstand the drought in the following year.

Yala Season

Mid March to end of March. Sowing with first intermonsoon rains

Gingelly, sun hemp, green gram, meneri and cowpea, may be grown :

The *maha* season rains normally begin between the middle of September and the first week of October and continue till between the first and second week in January, a period of about four months. In a soil where a low moisture supply has to be frequently replenished by rain the growing season for shallow rooted crops thus becomes very precisely defined.

Most crops with an age of 4-4½ months from sowing to harvest respond best when sown right at the beginning of the rains after the soil has become wet enough to cause germination. This spell of rain is almost invariably followed by a spell of dry wheather which last anything from a week to three weeks. With big seeded crops like cotton and maize which can be planted relatively deep in the soil to ensure germination, it has been observed that there is a marked reduction in yields if the first spell is missed and planting done in the next spell of rain which is usually heavier and of a longer duration. Plants sown late never make vigorous growth. If sowing is done in the dry spell more than four days after the first rains cease very poor stands result due to the fact that soils dry out too fast.

With small seeded crops such as kurakkan and mustard, sowing with the first rains carries a hazard. If the dry spell is longer than ten days the young seedlings are adversely affected or die out altogether. It would be safer, therefore, to sow just before or with the second spell of rain which, however, is often too heavy to allow seed drills to be used and often of a sufficiently long duration to delay seedling too late. Rains during this period consist of evening thunderstorms with bright hot mornings and the surface soil dries out sufficiently each day to allow a small seeded shallow planted crop to germinate and make satisfactory initial growth without being adversely affected by excessive moisture. The following general rules can now be framed to serve as a guide for further work :—

(i) Sowing dates of crops of different ages should be so arranged that harvesting could be done after the third week of January.

(ii) Large seeded crops of 4 to 4½ months duration which require excellent drainage conditions during germination and initial growth should be planted at the beginning of rains between the middle of September and first week of October. These crops should be planted relatively deep into a wet soil. Soaking of the seed overnight helps germination and improves stands.

(iii) Very small seeded crops should be sown shallow in a dry soil just before the second rains between the last week of September and the middle of October.

Crop Spacings. Spacing experiments indicate that the following spacings are optimum under Maha Illuppallama conditions :—

Crop	*Spacing in inches between rows*	*Spacing in inches within rows*
Maize (for grain)	36	36
Maize (for fodder)	24	12
Sorghum (for grain)	24	12
Sorghum (for fodder)	12	12
Kurakkan	12	6
Upland rice	12	6
Cotton	36	12–18
Chillie (transplanted)	24	12
Cowpea (for seed)	24	12
Cowpea (for fodder)	12	12
Pigeon Pea (pure)	36	12
Pigeon pea (mixed)	72	12
Groundnut (bunch type) on ridges	18	6
Groundnut (flat)	10	10
Deccan hemp (Hibiscus cannabinus)	6	6
Velvet Bean (for cover)	24	12
Velvet Bean (for seed)	36	12

Maintenance of Soil Fertility. Traditionally there are only two forms of land use developed in the humid and semi-humid tropical regions of Asia ; irrigated rice in the lowlands and alluvial plains and a forest fallow system of cultivation with annual crops (shifting cultivation) in the unirrigable uplands. The dry zone of Ceylon is typical in this respect.

The cultivation of rice in flooded, puddled, bunded and levelled fields has ensured a maintenance of soil fertility even on the poorest of soils and without any form of manuring. Complete weed control is obtained, no fallow periods are necessary, soil physical structure is of little importance and little or no erosion occurs. Rice cultivation has thus been able to support large populations in Asia continuously for

thousands of years. On the uplands on the other hand the cultivation of annual crops has always required the use of a long forest fallow from 10-50 years being required in different areas for the maintenance of fertility. Once population densities pass a certain critical level, a shortening in the length of the forest fallow results and a decline in fertility follows. Further increases in density without a change is the system of cultivation result in degradation of the land. It is clear that this system of upland cultivation unlike the cultivation of irrigated rice is unstable and is able to continuously support very small populations at subsistence level, in any given area. Traditionally no alternatives have been developed to meet increasing population density : the civilisation and tribes themselves have vanished.

Intensification of cultivation, therefore, presents difficult problems on the two systems of land use. With irrigated rice immediate increases in production are possible through determining direct responses to fertilisers, their optimum doses, best times of application and placement particularly in regions where there are no serious factors to production such as poor drainage, alkalinity, salinity, &c. With uplands crops the problems are more complex and are bound up with associated problems of erosion and weed control which have already been discussed. Here there is need for a more fundamental approach.

Irrigated rice experiments carried out at Maha Illuppallama to determine direct responses to N, P and K using ammonium sulphate, super phosphate and muriate of potash respectively and to organic manures have indicated that there are marked responses to nitrogen application with an optimum dose of about 40 lbs. N (200 lbs. of ammonium sulphate per acre). There is a marked response to phosphate with an optimum dose of $P_2 O_5$ (2 cwts. of superphosphate single per acre) only on the better drained rice fields with a small or no response on the poorly drained fields. There are also marked responses to green manuring and to compost. No responses to potash were obtained in any year.

On the better drained uplands fertiliser experiments have been carried out with cotton, chilli and sorghum between 1950 and 1955 to determine direct responses to N, P, K and compost using the same fertilisers as used in the irrigated experiments. The experiments were located on blocks of land that were being cropped in a four year rotation of cotton, legumes, chilli and cereal. No fertiliser was applied to the other crops in the rotation. There were marked responses to compost applications in most years ; increases in yields from 30-100 per cent. were obtained. The responses to mineral fertiliser has been erratic. Responses of the order of 20 to 30 per cent. to nitrogen and phosphate were obtained only in wet years while in the dry years there were no reponses at all. There were no indication of responses to potash in any of the experiments. With groundnut there were no responses to phosphate or to any trace elements.

All the above fertiliser experiments with upland crops were carried out on land clean cultivated with a disc plough and disc harrow. In recent experiments there have been indications of greater responses to both nitrogen and phosphate after the system of tillage was changed to a non-inversion type and where stubble and thrash are now left on the surface. In 1955-56 which was a

very dry year marked responses to both nitrogen and phosphate were obtained for the first time. In another experiment (Table VI) there was an indication of a greater response to phosphate with maize when it was sown in association with cowpea than when sown pure even in a system of trash mulch tillage. In another experiment with upland rice there was an indication of better response to phosphate when the phosphate was applied through a preceeding crop of sun hemp (*Crotolaria juncea*) rather than when it was applied direct to the rice crop. All these results can be taken as indications that there is a great deal more information required as to the rates and methods of application of mineral fertilisers chiefly phosphates.

The most important indication from all the experience gained so far is that the use of organic and mineral fertilisers alone have not been sufficient to maintain yields on the uplands. This fact is brought out in Table X.

Table X

	Pounds per Acre			
	Maha 52–53	*Maha 51–52*	*Maha 52–53*	*Maha 54–55*
Seed Cotton	1,092 ..	690 ..	492 ..	306
Dry Chillies	554 ..	214 ..	613 ..	250
Rainfall (September–January) in inches ..	23·19..	46·72..	15·00..	40·58
No wet days	57 ..	53 ..	30 ..	52

There has been a continuous decline in the mean cotton yield of the experiments from 1950 to 1955. These were located on different blocks of land that have been in cultivation and therefore do not give a true position of the decline in yields on any one block of land but illustrate the general decline in yields that has occurred in the station using a system of inversion tillage, mineral fertilisers and a four course rotation. Chilli is a shallow rooted crop and thus very susceptible to fluctuations in soil moisture content. The fluctuations in yield point clearly to the need for the maintenance of good physical structure in the soil.

Attempts to use a three to four year grass ley on the station for restoring fertility and rebuilding soil structure have so far not given the desired results. There were no marked increases in yield after the grass ley in either the first of second year after the ley was ploughed up. The results from first cycle of a rotation experiment are included here as merely being indicative of the trends.

Table XI

Indicator Crop Rotation Experiment Cycle	*Sorghum*	*Mean Yield per Acre Pounds*
A 3 years grass ley ..	(Bracharia/Stylosanthes)	625
B 3 years legume ..	(Velvet Bean in 1st year, perennial Pigeon Pea in 2nd and 3rd years)	1,780
C 3 years crops ..	(Sorghum/Pigeon Pea mixture in 1st year. Velet Bean in 2nd year. Cotton in 3rd year)	870
D 3 years crops ..	(Cotton in 1st year. Sorghum/Pigeon Pea mixture in 2nd year. Groundnut in Maha. Gingelly in Yala 3rd Year) ..	1,410

It is, therefore, clear that there is a need for more detailed investigation with particular reference to the application of mineral fertilisers and the maintenance and restoration of physical structure. For the present the greatest benefit is likely to come through the use of compost and farm yard manure and a non-inversion system of tillage.

Recent work on the soils of the dry zone are pointing the way to the development of a more rational system of fertiliser practice. The main seat of fertility is known to reside in the colloidal fraction or the clay.

Modern advances in the knowledge of clay mineralogy have lent considerable support to a better appreciation of many soil properties. A knowledge of the important types of clay minerals that occur in the colloidal fraction of the dry zone soils should give valuable information on several aspects concerning its fertility problems. X-ray diffraction studies show that the predominant clay minerals of the dry zone soils belong to the Kaolinite group (22). The contribution towards chemical fertility by this group of clay minerals is known to be very low, small amounts of montmorillonite or illite occur as well. It has already been pointed out that in the dry zone there is a catenary sequence of soils from typical non-laterized red earths to hydromophic variants of these in the direction of the slope from crest to floor of each minor valley.

Kaolinite is the chief clay mineral in the red-earths, the uppermost member of the catenary series which is located on the water-shed and upper slopes, with the montmorillonite content increasing in the lower soil horizons. Yet due to the relatively smaller proportions in which this occurs the exchange capacity of the soils is fairly low to medium. The cation distribution on the exchange complex, however, from an agricultural view point is much desirable. The high quantities of sesquioxide constituents present in the colloidal fraction of the soils on the one hand imparts the good structural properties to the soil, while on the other hand is responsible for much of the locking up of phosphate nutrients. Haematite is the chief sesquioxide mineral indentifiable in the clay fraction. The percentage of montmorillonite increases in the soils of the middle and lower slopes and in the soils of the bottom lands it is present in fair quantity. This

would impart to these soils a higher natural fertility than the soils of the upper slopes. Of the sesquioxide minerals Geothite increases in the same direction. There is thus a gradation in the chemical fertility of the soils series that constitute the catena based on the level of chemical nutrients present and on the requirements of the crops suited to the respective soil series. Nitrogen has to be supplied to all the soils. The phosphate requirements of the better drained upland soils have to be more systematically studied. In the lower members of the catenary series the phosphate is in a form available to meet the requirements of its crops.

The use of organic manures and crop residues can greatly improve fertility of the better drained uplands. Under conditions of good internal drainage in the soil type there is a rapid leaching of mobile nutrient constituents. This is accentuated in the absence of vegetation and thus there is need for maintaining a close cycle of nutrients through the medium of some vegetation. This would necessitate the use of (*a*) curing of the cropping season of mixed crops and systems of stubble mulching so as to ensure that a crop be continuously on the land (*b*) during the rest period of deep rooted crops that would return to the surface nutrients reached below the root zone of the crops or (*c*) a continuation of (*a*) and (*b*) during the cultivation period. Experiments with these objectives are in progress.

Crop Improvement. Before 1950 cotton was grown as a dense crop but was dropped from cultivation after the import of cheap cloth from England and India. The variety used was a short staple eight months variety that was sown in *maha* and picked in *yala*. No cotton is now grown on the *chenas* of the North-Central Province. Attempts to introduce the cultivation of a medium staple 5 months variety have proved successful so far only in the south of Ceylon. The demand for kollu (*Dolichos biflorus*) which along with green gram and black gram were the chief pulses of the dry zone was greatly reduced after the large scale importation of Mysore dhal and Tur Dhal began. Importation of wheat flour and its spread in the country after the war has reduced the demand for kurakkan, the minor millets and maize, reducing still further the demand for traditional *chena* crops. It may be that advances in food technology may make possible again the utilisation of these traditional crops, but at present they have only a limited demand.

The crop improvement programme at Maha Illuppallama is planned with a view to introducing and testing as wide a range of new crops as possible. Attention is also being given to the search for possible economic perennial crops; so far, however, the emphasis has been on annual crops. Extra attention is also been placed in the selection of a suitable drought resistant perennial legume cover crop and on the introduction of as wide a range of pasture and fodder grasses and legumes. Trials carried out by the Department of Agriculture in the last twenty years have shown that the following crops perform quite satisfactorily in the dry zone-maize, sorghum, cowpea, pigeon pea, groundnut, Deccan hemp (*Hibiscus cannabinus*), castor (*Ricinus communis*), soyabean, chilli, tomato and tobacco. A brief review of the progress made in the last four years is presented here.

Cereals and Millets. The objectives of the sorghum improvement programme are the production of (*a*) high quality, high yielding grain sorghum, preferably a dwarf type with open panicle and small white grain and (*b*) a high yielding dual purpose sorghum of high quality. 16 varieties of grain and dual purpose sorghums were included in the yield trial set down for *maha* 1954-55. The dual purpose varieties San Pyaung, CO 2 (tall open panicle small white grain types) and Nadujal, Fulgar Yellow (compact panicle layi grained types) are extremely promising. Among the grain types AS 475 and I. P. I. Jawar 3 (open panicle types with small grain, medium height) and Combine Black Kaffir (dwarf type with compact panicle and large grain) were promising. These varieties have been included in a smaller yield trial of 12 varieties for *maha* 1955-56. Several of the newer grain sorghum introductions also showed promise, and are being multiplied in *maha* 1955-56 so as to secure sufficient seed for inclusion in later yield trials. The fodder variety Sweet Honey continued to outyield heavily all the more recent introductions and remains the best fodder variety available.

Work on maize was commenced at the station in *maha* 1954-55. Over 35 varieties—foreign and local open pollinated varieties, and a few of the Botanist's top-crosses were observed, and on the basis of these observations 12 varieties 10 open-pollinated varieties and 2 top-crosses—were selected for inclusion in a yield trial in *maha* 1955-56. During 1955 over 50 foreign varieties of maize —largely open-pollinated flint types have been introduced. These have been set down in observation plots for *maha* 1955-56, along with over 50 local NCP varieties.

Five varieties of kurakkan (*Elusine coracorna*) and three varieties of tanahal (*Setaria italica*) were introduced from India and tested against two local varieties in 1954-55. The kurakkan introduction RAGI CO 1 and the tanahal introductions SI—COI and SI—CO 2 are promising. A yield trial of kurakkan and tanahal varieties has been set down for *maha* 1955-56—the varieties comprising the 8 introductions referred to above and a control variety of both kurakkan and tanahal. Four varieties of *Pennisetum typhoideum* have been introduced and are being observed.

Leguminous Food Crops. Work on the improvement of pulses is being conducted on pigeon pea (*Cajanus Cajan*) Cowpea (*Vigna spp*) soya bean (*Soja max*) and green gram (*Phaselous aurecus*). Improvement in pigeon pea is being directed towards evolving (*a*) an annual short bush type giving a high seed yield and (*b*) a perennial short type giving a high seed yield—for primary use as a soil renovating rest crop. Over 50 introduced varieties of pigeon pea were observed in *maha* 1954-55 and the varieties classified into annual bush types and perennial shrub types. Larger observation plots of all these varieties have been set down for *maha* 1955-56. During *maha* 1954-55 single plant selections for simultaneous flowering and high seed yield were made within the annual seed types. The selections have been carried into progeny rows in *maha* 1955-56.

The yield trial of Tur 5 selections against unselected Tur 5 and Tencasi was continued in *maha* 1954-55—the number of selections being restricted to five. The results were inconclusive and trial is being repeated in *maha* 1955-56. Tur 5-58 and Tur 5-85 are however the most promising selections.

Cowpea. 12 cowpea varieties were included in a yield trial in *maha* 1954-55—these varieties representing the most promising varieties of the 25 tested during *maha* 1953-54. The introductions Arlington and Brown Crowder significantly outyielded the control variety Bombay Cowpea—the yields increases being of the order of 40 per cent. and 17 per cent. respectively. The local variety Chilaw 5 yielded as high as the control variety Bombay Cowpea, while all the other varieties gave significantly lower yields. The trial is being continued in *maha* 1955-56. There are 18 other varieties under observation.

Soya Bean. An yield trial of 12 soya bean varieties was set down for *maha* 1954-55. The variety Yellow gave by far the highest yield—significantly outyielding the varieties Chame and 34-S-51—which do not differ significantly—by just over 40 per cent. Most of the other soya bean varieties gave extremely low yields and trial has therefore been amended to include four green gram varieties, the standard black gram variety and only 7 soya bean varieties. This new trial of minor pulses has been set down for *maha* 1955-56.

Individual plant selections were made in the more promising soya bean varieties in *yala* 1955. and these selections have been varied into progeny rows in *maha* 1955-56. Individual plant selections were made in the more promising soya bean varieties in *yala* 1955, and these selections have been carried over into progeny rows in *maha* 1955-56.

Groundnut. The yield trial of 12 groundnut varieties was continued into the third season in *maha* 1954-55. The varieties Red Spanish and Uganda Erect again gave significantly higher yields—reaffirming the results over the past two seasons, viz., *maha* 1952-53 and *maha* 1953-54. Several new varieties were introduced during 1955, and in *maha* 1955-56 over 40 varieties of groundnut were set down in observation plots.

Of the other miscellaneous legumes tested, *Mimosa invisa* has confirmed its earlier promise of being a good ground cover. This species nodulates profusely and forms a thick ground cover very rapidly. The cover must be sown only by *mid-maha* or later, as earlier sowing leads to profuse flowering and consequent setback to the vegetative growth.

Pasture Legumes and Grasses. Several varieties of grasses and pasture legumes are under test. Most of the grasses have proved drought resistant, while of the legumes the indigenous sepecies *Alyiscarpus vaignalis* is particularly promising. Four species of *Stylosanthes* are under trial but the initial growth was somewhat slow. Nearly 80 varieties of lucerne have been introduced and have been set down for *maha* 1955-56.

Upland Rice. A greater part of the review has so far dealt with problems of utilization of dry land in general with particular reference to the well drained uplands. The lower unirrigable lowlands which are more fertile but poorly drained in *maha,* constitute a large class of land, the utilization of which is important. Experiments carried out at Maha Illuppallama during the last three years are beginning to show that the rainfed (upland) rice can be grown quite satisfactorily on this land class, normally a higher rainfall is required during the growing season of upland rice but on this land class there is also probably a benefit from the proximity of the ground water table. The main problem appears

to be one of weed control and when fields have been kept free of weed, good crops have been obtained. Investigations into methods of rain-fed rice cultivation, however, have a wider application in the dry zone where irrigation water supply is often very limited, and frequent failure of irrigated rice occurs. Any practice that will result in a reduction of the duty of water will have immediate and wider application.

The general considerations discussed earlier in relation to soil erosion, tillage, weed control and time of sowing apply here also with the difference that a system of bunded level contour terraces can be used in which a greater part of the rainfall can be retained. Provision has, however, to be made for the disposal of storm water from very heavy storms.

Rice is very sensitive to weed competition particularly in the early stages of growth. The results obtained from an experiment at Maha Illuppallama illustrate this point.

Table XII

	Yield per Acre Pounds	*Per Cent. of Control*
Pre Sowing Treatments—		
No cultivation at time of sowing	1,301	100
Cultivation at time of sowing	2,021	155
Time of First Weeding—		
10 days from sowing	1,944	100
15 days from sowing	1,666	84
20 days from sowing	1,323	66
Number of Weedings—		
3 weedings at 10-day intervals	1,614	100
6 weedings at 10-day intervals	1,708	106
Significant difference	320	—
Unweeded control plot	—	—

It is clear that an early weeding is essential and that a cultivation operation at the time of sowing will naturally reduce weed competition. With the practice of sowing into a dry soil it is thus vitally necessary that, as weed free a seed bed as possible be obtained and that weeding be done within 5 to 10 days from sowing.

Planting a crop in rows greatly facilitates weeding and from spacings experiments it has been found that a spacing of 12 inch drill rows, with approximately 4 to 6 inches within the row is optimum. For early weeding with an implement, the rotary hoe has been found to be most effective. This implement can be drawn by a pair of bullocks or by a tractor and can be driven right over the rice crops without much damage to the young seedlings. The rotary weeder is effective only on small weeds and therefore has to be used early. In many years, however, the fields become too wet for the use of implements and weeding cannot be done at the correct time.

Experiments with chemical weed killers at Maha Illuppallama during the last three years have shown that 2 4 D and MCPA applied at rates from $\frac{1}{3}$–$\frac{1}{2}$ gallon in 20-30 gallons of water per acre are very effective in the control of most broad leaved weeds. No abnormalities in the rice plants were observed and only very negligable reductions in yield were obtained if these weed killers

were sprayed after the crop was 18 days old. Earlier applications damaged the rice plants. With the use of these weed killers there has, however, been an increase in the grass components of the weed—flora and the problem of weed control in the upland rice fields has resolved itself to the control of grass, chiefly *Echinocloa colona, Digitaria* species, *Chloris barbata and Cynodon dactylon.* These grasses now completely swamp the rice crop in fields where the tillage operations have not been effective. In attempting to obtain a control over the grasses it has been found that use of sun hemp in the *yala* season greatly reduces weed competition in the following season. The use of pre-emergence weed killers also offers some promise. A number of weed killers have been under test and these are indications that the use of DNBP and a mixture of MCPA and 245 T may prove effective as pre-emergence weed killers if applied just after the rice has been drilled. The plots remain relatively clean for about 15-20 days after application and during this period a mechanical or hand weeding can be given when the weather conditions are right. The used of DNBP however carries with it certain hazards and a great deal more work will be necessary before a technique for its use can be perfected. As many new weed killers as possible will be included in future experiments.

Normally a 4 months variety of rice is grown on the rice *chenas* in the Province. Experience has shown that a 3½ months variety is less liable to fail in dry years. The varietal improvement programme has therefore the solution of a 3½ months drought resistant, high yielding strain as one of its chief objectives. Five hundred progenies from crosses between local and introduced upland varieties are under test. 42 varieties from different tropical countries are under study. In yield trials with local and introduced varieties a number of the latter appear promising. Three 3½ months varieties, in particular, Betion 11 from Nigeria, Waner from Indonesia and PTB 28 from India warrant mention.

Animal Husbandry. Probably the greatest single factor than can stimulate the development of upland agriculture and in turn contribute directly to the prosperity and health of the country is the development and integration of animal husbandry (particularly the production of milk) with the upland cropping system. In nearly every village in the dry zone there are large herds of cattle that are not used for any purpose. Tons of cattle manure are wasted annually. The basic raw materials for the development of a balanced agricultural system within each village are thus present and it is very probable that the development of a market for milk through the organisation of milk collecting schemes can set in motion the beginning of animal husbandry development in the dry zone, which will create a need for better animals, better pastures and fodders. Simultaneously the collection of cattle manure and the preparation of compost can be organised into systematic manuring and penning of animals on the uplands and other cropping area introduced for it is obvious that whatever system of upland cropping develops, organic manuring will for many years to come form the basis of fertility maintenance in the dry zone. The inclusion of animal husbandry will provide work during the long, dry, lean months when there are no crops in the field and also produce a steady income during those months. There will

also be a better utilization of land. The present grazing lands of any village are the fallow paddy fields, the tank bed, the low lying lands adjoining the tank and abandoned *chenas*. Ground water studies at Maha Illuppallama have shown that soil moisture conditions are favourable for a large part of the year for the production of pastures and fodders on the paddy lands and the low lying unirrigated lands that are partially water logged in *maha*. The utilisation of the fertile unirrigable lands for animal husbandry and the production of compost for use on the unirrigable uplands will maintain a cycle of fertility and is a system to be aimed at.

Animal nutrition trials are in progress at Maha Illuppallama and it is proposed to start a series of trials with Tharparkars, Sahiwals and Scindhi under dry zone conditions.

Lift Irrigation. It is likely that there may be considerable scope for development of systems of lift-irrigation direct from tanks and channels and from seepage wells for the intensive cultivation of limited extents of perennial forest crops and market garden crops and for supplementary rainfall on the uplands. Investigation of those aspects will form an important branch of work at Maha Illuppallama. Experiments are in progress with the cultivation of citrus and other orchard crops with lift irrigation from irrigation channels and to determine the possibilities and costs of growing vegetables with water from wells located along the edges of paddy fields.

Land and Water Use. From earlier considerations it is clear that for conservation and utilization of water, the indigenous system of surface storage tanks if effective and well adapted to the dry zone environment. For maximum and efficient conservation of water as many tanks as possible in a given area as is compatible with the water reserves of the area will have to be constructed. This will involve a knowledge of the water resources and the hydrology of the area and will require planning in terms of whole river, tributary and streams catchments as basic units of varying size. For stable development of land resources the smallest unit of development will probably have to be the tank and its immediate catchment area which is referred to here as the 'tank unit'. The immediate catchment area of each tank unit will consist of one or more primary catchment basins, each of which will have to be treated as a single or smallest unit of water management for efficient control and disposal of storm water. It is clear that requirements of stable development and efficient water management will impose joint responsibility and a joint need for conservation on all owners of land in a tank unit. The requirement will also automatically have to be extended to each stream and tributary catchment and finally to the whole valley itself.

Attention has been drawn to the existence within each primary catchment basin of definite land classes requiring differences in land use or irrigable lands; different crops will have to be located contour-wise across the slopes from crest to floor according to their degree of tolerance to waterlogging. A scheme of land use based on the present state of knowledge is summarised below:—

Land Class VI

Watershed, steep land and rocky out crops, shallow skeltal red—red brown soils.

Forest, windbreaks for fuel, and timber, Mango, Cashew Nut and probably Palmyrah.

Land Class V

Upper slopes, red—red brown soils, arable crops, on best land, permanent crops such as Mango, &c., on shallower soils.

Land Class IV

Middle slopes, brown—grey brown soils, arable crops, pastures and fodders, sugarcane * possible development of perennial crops and market garden cultivation with lift irrigation on small extents.

Land Class III

Lower slopes, grey—grey brown soils, upland rice, pasture and fodders.

Possible development of vegetables and market garden cultivation with lift irrigation on small extents.

Land Class II

Relatively well drained lands influenced by seepage from tanks and channels, brown—grey brown soils.

Perrennial crops, such as citrus, jak, breadfruit, coconut, plantains, papaw, &c.

Possible extension of above cultivation with development of lift irrigation.

Land Class I

Grey to glei soils.

Irrigated rice where this is possible, unirrigated rice, pastures and fodders.

Possible development of market garden cultivation with lift irrigation on small extents.

On land that is entirely irrigable the basic drainage pattern within a primary catchment basin does not alter very considerably except that the groundwater table is higher. Here rice can be grown in rotation with irrigated crops and sugarcane on the upper and middle slopes and on the lower slopes with some drainage. Rice will have to be cultivated continuously in the bottom lands. It has not been possible to grow irrigated crops successfully if cultivated alongside with rice in the same land class in the same season in a primary catchment basin.

It would thus appear that under the environmental conditions of the dry zone a diversified system of land use is inevitable even on relatively small extents of unirrigable lands. This principle will also apply to irrigable lands if attempts are made to grow irrigated crops other than rice that require good drainage.

Two other points need repetition here —(i) Soil moisture conditions have to be artifically created for the growth of drought susceptible perennial crops which will thus be confined only to specific areas where such conditions have been created. (ii) It would appear

* Detailed investigations are required. Experience with sugarcane cultivation at Maha Illupallama between 1947 to 1951 indicated that it may be possible to grow sugarcane on this land class without irrigation.

from present knowledge that the inclusion of the unirrigable uplands and lowlands and irrigable lands in a single system of mixed farming will ensure a better utilisation of land and a better conservation of soil fertility. The inclusion of irrigable and unirrigable lands in a single system also ensures a certain degree of stability in a variable rainfall that has opposite effects on the success of irrigated rice and upland crop cultivation.

The foregoing considerations and the need to keep in mind the possible development of mechanisation in the future have important implications with regard to the design and layout of colonisation schemes and on land alienation in the dry zone. It may be that cooperation or group farming, traditions for which already exist in the indigenous tank village agricultural system may prove better adapted to the dry zone environment.

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Farming in the Dry Zone in Ceylon — Some Observations and Comments on Problems and their Solutions

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Farming in the Dry Zones of Ceylon is confined to paddy production on irrigated land in the valleys below the tanks, tree fruit production in home gardens on high water table areas adjoining the tank, swamp grass and rainfed paddy in the poorly drained land above the irrigated paddy, production of cereals such as kurakkan, sorghum, maize, cowpea, gingelly, pulses like green gram and black gram as mixed crops in *chena,* and vegetables of all kinds, as well as cotton and hemps for fibre are common on the highlands. Livestock is raised for the production of animal power, cattle manure, milk, meat and eggs.

The cultivators in the Dry Zones live in the villages and farm the paddy land associated with the village and the highland (*chena*) allocated to them each year in the catchment area around the tank and village.

Until the implementation of the guaranteed marketing system, revenues from agricultural produce fluctuated to such an extent that the income provided only subsistence for the cultivator with nothing to provide incentive for extended effort or to invest in tools and labour to increase revenue.

Proven production techniques to ensure increased paddy yields available to the cultivator are viz. :

1. Improved paddy land preparation using the little iron plough and other tools to prepare a weed free, level seed bed for paddy production.
2. The use of pure-line seed selected for the season and the area.
3. Propagation of paddy nurseries for transplanting.
4. Transplanting paddy into the fields instead of broadcast seeding.
5. The use of fertilizers.
6. Weeding paddy fields during the early stages of growth, by hand or with the harrow.
7. Protection of paddy fields by fencing. Where land tenure practice insured the tenant cultivator of reasonable security, he was able to increase yields of paddy.

Proven production techniques are not available, however, for highland cultivation other than those of *chena* with forest fallow.

1. Forest fallow provided soil protection and fertility as well as weed and insect control as long as

there was sufficient land to permit fallow of 10 years or more. With the need for more land annually under cultivation in each village, the fallow period is being shortened to such an extent that soil fertility regeneration and weed control are not being maintained.

2. Permanent agriculture will need to take the place of *chena* where the pressure of population and annual land use render the forest fallow ineffective.

   Permanent agriculture must provide land and crop classification, land use with rotation which will provide soil conservation measures, soil fertility balance, crop residues mulch and cover and rotations of commercial crops which will control weeds, insects and maintain soil structure with the use of the tools, implements and labour available to the cultivator at his economic level.

3. Research in production techniques in the Dry Zones of Ceylon has been the function of the Department of Agriculture for many years. Interuptions caused by world wars, the shortages of food and food production programmes as well as changes in Directors of the Department of Agriculture and subsequent programmes have hindered fundamental research not only in paddy production under irrigation but also highland production of rain-fed crops, fruits and livestock products.

Fundamental research in the problems of production in the Dry Zone has been centred at the Agricultural Research Station at Maha Illuppallama since 1950.

While climatic conditions and soils vary in the three Dry Zones of Ceylon, the fundamental classification of soils and crops as associated with the tank and village is the same. The basic problems of soil conservation, soil fertility, soil structure, weed and insect control are similar, so that only variations of application and implementation of the fundamental findings will be necessary in the various Dry Zones. These will be conducted and outlined in detail at the Agricultural Stations in the Dry Zones before being demonstrated to the cultivator through the Agricultural Extension Service.

The New Zealand Government has provided very valuable Colombo Plan Aid for buildings and facilities necessary for modern housing for staff at all levels, laboratories, shops and facilities to establish high standards of living and working conditions so essential to a happy, efficient, scientific staff. Research in Dry Zone agricultural problems is a long term scientific study of soils, climate and production, which requires years of concentrated continuous research. Modern living conditions at the station with up-to-date laboratories and equipment largely compensate for its isolated position.

A scientific staff of trained young men is being assigned to the Agricultural Research Station at Maha Illupallama as accommodation and facilities become available and as staff return from special training abroad. Specially trained personnel in Agronomy, Plant Breeding, Soil Science, Soil Conservation, Agricultural Engineering, Farm Management and Agricultural Economics, Animal

Husbandry, Plant Pathology and Entomology along with Agricultural Instructors and Field Assistants trained in these various subjects and a clerical staff to record and implement the details of the station are working together with the Agricultural Research Officer as the head.

Very valuable guidance is provided by the senior members of the Department of Agriculture through the many associated committees in practically all of the specialized fields.

Since the establishment of the Agricultural Research Station in 1950 at Maha Illuppallama many of the basic problems have been defined, viz. :—

1. Land use in the Dry Zone.
2. Land and crop classification.
3. The scientific basis underlying *chena* cultivation.
4. The recognition of the tank-village as a natural unit of settlement.
5. The climatology of the dry zone with high and low levels of rainfall, variations of water table and limitations of monsoonal distribution.
6. Soil conservation.
7. Maintenance of soil fertility.
8. Tillage and weed control.
9. Crop improvement.
10. Crop protection.

Observations of the interest of the cultivator in agricultural techniques affecting him, his understanding of fundamentals and recognition of limitations, his reactions to incentives provided by a stable market for agricultural products, and his diligence and industry all anger well for development of the Dry Zone into an area of comfortable homes supporting a well balanced permanent agriculture which will with intensive culture support a dense population.

Research which will assist in the development of the Dry Zones of Ceylon is being conducted along the following lines :—

1. The intensification of production in the various classes of land.
2. The selection of new crops to meet the demands of a changing economy and diet habits.
3. The integration of animal husbandry within the village agricultural system.

Applied research in the Dry Zone Agricultural Stations, a competant Agricultural Extension Service and an interested farming community will, no doubt, insure the use of proven scientific techniques necessary for high production through a system of permanent agriculture in the Dry Zones of Ceylon.

The Progress of Dry Farming Schemes in Ceylon

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The following dry farming settlement schemes have so far been established :—

1. Kurundankulama, 4 miles east of Anuradhapura on the Mihintale Road in 1938 with 10 families, subsequently extended to settle another 40 families.
2. Makalanagama, 2½ miles from Galgamuwa in N. W. P. on the Ehetuwewa Road in 1943-44 with 22 families.
3. Relapanawa, 13 miles west of Anuradhapura on the road to Puttalam in 1950 with 40 families.
4. Olukaranda, 25 miles from Anuradhapura (3 miles from Kekirawa) on the Anuradhapura-Matale Road in 1950 with 7 families.

Kurundankulam

This Dry Farming scheme was started by the Department of Agriculture in 1938 on an unirrigable block of 100 acres at Kurundankulama, 4 miles east of Anuradhapura on the Trincomalee Road with the object of :

1. ascertaining whether the Wanni villager could be trained to take to dry land arable farming.
2. to ascertain the extent of unirrigable land an average peasant family could farm efficiently using simple bullock drawn implements and the income that could be obtained therefrom.
3. whether the fertility of soil could be maintained under the prevailing conditions of rainfall.

Attempts to secure ten typical Wanni families to form the settlement proved futile owing to the reluctance of the conservative Wanni villager to leave his home. Only one Wanni family was included in a settlement of 10 families in January 1939. Some of the selected families either abandoned their allotments or were weeded out. Today only one of the originally selected ten families remains. The ten families in occupation at present have been working for various periods from 3 years to 17 years.

A block of 100 acres was divided into 10 equal blocks, each having a road frontage ; the first acre by the road frontage being used as the homestead. Development of the allotments was done in stages beginning in January 1938. It was intended to clear and stump progressively each year an extent that each family could develop. A subsistence allowance of Rs. 15 per month was paid until the whole allotment was rendered arable. Very soon the Department realized that it was beyond the economic capacity of the settlers, to develop the holdings expeditiously. The Department thereupon rendered the holdings arable at State expense, the settlers themselves receiving wages for the work done.

By September 1943 the development of the 10 holdings was completed. Each

holding was 10 acres in extent, of which one acre was used for the homestead. A wattle and daub house was provided. The homestead was planted with 30 citrus plants, 8 mango grafts, 12 coconut plants and a few miscellaneous plants such as jak, breadfruit, pomegranate, &c., and a small area inter-cropped with plantains, was set apart for vegetables. Wells were provided. A cattle shed and a poultry run were also constructed in the homestead.

The remaining allotment of 9 acres was cropped according to the following rotation :—

Block A—6 acres—

1st year—*Maha*—Chillies
Yala—Pulses

2nd year—*Maha*—Cereals
Yala—Gingelly

3rd year—*Maha*—Cotton
Yala—Cotton continued

Block B—2 acres—

1 acre Bananas for 5 years

1 acre Napier grass for 5 years (these two crops to be rotated).

Block C—1 acre—

Permanent Paddock.

Each settler was given a pair of draught bulls, one cow, a pen of poultry and essential bullock-drawn implements and tools. They worked their allotments individually. An Agricultural Instructor stationed at the spot advised them.

In 1948 the settlement was extended by the addition of 84 acres to be worked by 6 families co-operatively. The entire extent was cleared and rendered arable and permanent cottages were constructed at State expense. Each settler was allotted 14 acres made up as follows :—

2 acres for the homestead to be worked individually.

6 acres for arable farming to be worked co-operatively for 4 years.

6 acres to be utilised for stocking for 4 years and thereafter to be ploughed for arable crops.

The 84-acre block was divided into three, the middle block being used for the homesteads and the other two for cropping and stocking. Settlers farmed 36 acres co-operatively and utilized 36 acres for stocking their animals. By 1949 three settlers were removed for bad behaviour. They were replaced by a better type of peasant.

The topography of the land the 10 settlers farmed was fairly typical of the dry zone of the North-Central Province, being slightly undulating with valleys in between. Soil conservation had not been planned on the catchment basis ; instead individual blocks had been soil conserved. This resulted in the low-lying area which formed about 20 per cent. of the total being waterlogged. The settlers who were obliged to cultivate the low-lying, ill-drained blocks were decidedly at a disadvantage. The chief troubles were the unequal distribution of suitable land for farming and ineffective soil conservation measures.

In 1949-50 the entire settlement was re-soilconserved on the catchment basis with broad-based, graded bunds. All the run-off from the catchment was diverted into an abandoned tank and a pond within the settlement. The low-lying areas were *asweddumized* for rain-fed paddy.

Farm tank with colonists' cottages in the background

Settlers' cattle quench their thirst at the farm tank

A group of 10 new cottages constructed on a hillock, with two acres as homestead per settler replaced the old wattle and daub cottages that were contructed in 1938. A new road was constructed to serve the new group of houses and the two groups of settlers. A well 38 feet deep and 30 feet in diameter was provided for 10 settlers.

More equitable distribution of land was secured in 1950 by converting the settlement into a co-operative farming unit. Units of allotments and systems of cropping were changed. Settlers were given a two-acre homestead each and farmed 120 acres co-operatively. The 10 settlers cultivated 60 acres in arable crops co-operatively, and used 60 acres for stocking cattle. Cropping along the contour in terraces or bays was introduced and the following rotation adopted :—

1st year—*Maha*—Cereals Sorghum, Kurukkan, Maize

Yala—Sorghum ratooned

2nd year—*Maha*—Chillies

Yala—Chillies

3rd year—*Maha*—Cotton

Yala—Cotton continued

4th year—*Maha*—Pulse mixture with Dhal spaced widely for shade

Yala—Gingelly

Low-lying areas were cultivated with paddy as a rain-fed crop. To enhance their income the settlers are allowed to cultivate vegetables during the *yala* season with lift irrigation.

Thus two groups of settlers commenced farming co-operatively—one group of 6 farmers and the other group of 10 farmers. Each group selected its own leader or *Gamarala*. The selection of a leader is done annually before the commencement of the cultivation season. The members of each group are guided by their leader in all the co-operative farming operations. The leader in turn acts under the guidance of the Agricultural Instructor in charge of the settlement. Before commencement of the cultivation season in October 1950, the settlers moved into their new cottages. Lots were drawn for the cottages. The ten settlers that embarked on a new venture of co-operative farming, after about 10 years of working their allotments individually, happened to be a heterogenous crowd and they found it difficult to pull together. At the end of the season, of their own accord they requested that the group be split up into two units of five each. Their request was granted and the land blocked out accordingly. The total produce harvested by the co-operative unit is divided between the settlers according to the number of labour units contributed by each family. The *Gamarala* keeps a record of the labour units contributed by each family.

Extension of Dry Farming Schemes—Kurundankulama and Relapanawa

In 1950 the Minister decided to open two dry farming schemes to settle 40 families on each. Two sites were selected in consultation with the Revenue Officers. One site was at Kurundankulama, the extension covering an area adjoining the established dry farming scheme.

The second site selected was close to Relapanawa Village, 13 miles from Anuradhapura on the Anuradhapura-Puttalam Road.

Development of the Land. The clearing of jungle, stumping, rooting, levelling ant-hills, construction of roads and restoration of abandoned tanks at

Kurundankulama were done by the Land Development Department using D8 tractors with bulldozers and rooters, while at Relapanawa these operations were done by the Agricultural Labour Corps with machinery and with labour. The Agricultural Officer being in charge of the two schemes, all these operations were done under his supervision. All the colonists' cottages, latrines, wells and the general buildings such as the school, school master's quarters, manager's and conductor's quarters, meeting hall, co-operative stores and dispensary were constructed by the Land Development Department.

The entire planning and lay-out of the whole scheme, siting and demarcating wind belts, siting of tanks, ponds and groups of cottages and general buildings, tracing of the network of roads, soil conservation of the catchment basis, fencing, &c., at both the schemes, were done by the Agricultural Department.

Lay-out. Belts of forest, 300-500 feet wide, spaced every 2,000-2,500 feet apart were left along the ridges to serve as wind breaks and as fuel reserves. The space between any two wind belts depends on the topography of the land. The undergrowth of these wind belts was cleared leaving intact all valuable timber trees and other trees with good spreading crowns. Uneconomic and useless trees such as *veera* can be exploited for firewood and the gaps planted up with useful trees such as *halmilla,* teak, mango and cashew. 83,000 *halmilla* seedlings have been planted in the wind belts and along the fences at Kurundankulama and 14,000 at Relapanawa. Of this about 10 per cent. have survived at Kurundankulama and about 5 per cent. at Relapanawa.

Breached tank bunds in varying stages of disrepair were found in almost every catchment at both centres, seven at Kurundankulama and six at Relapanawa after the land was cleared and the jungle burnt. All the farm tanks, thirteen in number, were restored by filling the breaches, widening and raising the bunds, by heaping the soil excavated from the beds in the process of deepening. This was done with heavy earth-moving machinery.

The cleared area was soil-conserved on the catchment basis with broad-based, graded bunds. Fields in the valleys that get water-logged during heavy rains were *asweddumized.* The storm water drains leading from the ridges were diverted to the tanks. All the run-off water from each catchment was harnessed and stored in these tanks. Apart from the beneficial effects of the gradual raising of the water table, the stored water would be very useful for domestic and stock purposes, and for cultivation of vegetables, &c., during the *meda* and *yala* seasons.

The 80 homesteads of 2 acres each—40 each at Kurundankulama and Relapanawa, have been grouped in units ranging from 4 to 9 houses ; each unit, being provided with a common well 15 feet in diameter and 30 feet deep. All the homestead units have been located on the upper reaches of the farm tanks.

Barbed wire fences have been erected round the perimeter of the homesteads units and round the blocks to be cultivated co-operatively by the colonists. The blocks to be cultivated co-operatively are divided into two sections, one section for the cultivation of crops and the other to be rested and stocked. The blocks carrying crops of paddy are also perimeter fenced. Kapok, *halmilla,*

Co-operative Stores—Kurundankulama

Entrance to the Kurundankulama Scheme

mango and shade trees have been planted along the fences to serve as replacements for fence posts.

Buildings. Each allottee is provided with a type plan cottage and a temporary cattle shed. One temporary shed is also provided for each unit to serve as a store for carts and implements and also for the produce of the co-operative blocks as these are harvested.

A separate block of about 10 acres has been reserved at each centre for a school for children, quarters for the school master, co-operative stores, dispensary, meeting hall and play ground. Co-operative stores function at both centres.

Quarters are also provided at each centre for an Agricultural Instructor and a Conductor.

The lay-out of each scheme is shown in Table I.

Table I

Lay-out	*Kurundankulama (extension)* *Acres*	*Relapanawa* *Acres*
Gross acreage opened up	1,068	677
Number of farm tanks restored	6	6
Allowance for tanks at full supply level	34	40
Wind belts	225	60
Reads and drains	12	5
General buildings and quarters for officers	12	12
Acreage actually cultivated	448	320
Acreage rested for pasture	336	240
Total	1,068	677

Selection of Allottees. It was decided to give preference and priority in the selection of allottees to landless married men who had undergone a training at the various practical Farm Schools maintained by the Department of Agriculture. A Special Land Kachcheri notice was drawn up for the Dry Farming schemes by the Land Commissioner in consultation with the Agricultural Officer, Dry Farming.

Land Kachcheries were held at Colombo, Galle, Matara, Kegalla, Kurunegala and Anuradhapura. The response was very disappointing as most of the married candidates that were eligible for application were already employed as Food Production Overseers, Demonstrators and Administrative Secretaries of C. A. P. & S. Societies. With a view to give those still unemployed a further chance, the marriage qualification was not enforced and fresh land kachcheries were held when 39 passed-out students were selected from various parts of the Island. 23 allottees for the remaining 41 allotments were selected from landless peasants, priority being given to those residing in the North-Central Province.

Some of the cottages were not ready for occupation until the end of November 1951.

At the end of December 1951, sixty-two allottees had been selected and were residing in the allotments as detailed below :—

District	*Allottee*	*Kurundankulama*	*Relapanawa*	*Total*
Kegalla	Students	16	9	25
Kurunegala	Students	4	1	5
Kandy	Students	1	—	1
Kalutara	Students	2	—	2
Colombo	Students	1	1	2
Matara	Students	4	—	4
N. C. P.	Peasants	—	23	23
		28	34	62
Vacancies to be filled by peasants		12	6	18
		40	40	80

Out of the 39 students selected, 32 were bachelors and 7 were married. The bachelors arrived with a helper or two as instructed, but in most cases the helpers left them after a short time. The work as such was by no means an easy task with the result that settlers were forced to attend to the homesteads and neglected the Co-operative Units.

Strenuous efforts were made by the visiting and resident officers at persuading these student allottees to settle down to work. Their helpers would perhaps have not left them had these care-free bachelors refrained from adopting a superintending attitude. When the helpers left, these allottees expected the crop of certain units sown for their use, as they were late to take up residence, to be also gathered and delivered to them at Government expense. Even the valuable grafts and other plants supplied free by the Department for planting in their homesteads were neglected. Twenty two student allottees unfitted for this type of work left the allotment before they were expelled, and all the vacancies were filled by landless peasants. The set-up at the end of 1954 was as follows :—

	Kurundankulama	*Relapanawa*
Student Allottes—		
Married	1	
Bachelors	2	2
Landles Peasants—		
N. C. P.	10	14
N. W. P.	6	4
C. P.	21	9
Uva	1	—
Sab.	12	6
Western	2	5
South	1	—
Total	56	40

Scheme of Work. All the Dry Farming schemes are worked on the principle of co-operative tenant farming. In this type of farming the members do not own the land, but it is owned by society. At present the land is owned by the State, but when the societies are well established the proposal is for the societies to own the land. The land is divided into different blocks and each block is farmed co-operatively according to the planned programme by a number of families ranging from 4 to 6 in a unit.

Each settler is given 14 acres of land, of which 2 acres are for his homestead to be worked by him and his family individually. The remaining 12 acres form part of the undivided portion of the land held in common by the unit or group to be farmed co-operatively by all the members of that unit. Out of the land held in common by the unit for co-operatively farming half the extent would be farmed by all the members of that unit, and the remaining half would be rested as grazing ground for all the cattle belonging to the members of the unit. For example, if a unit is composed of 6 families, the total extent of land allotted to them would be 84 acres. Of this, 12 acres would be utilized for the homesteads at the rate of two acres per family. The remaining 72 acres would be farmed co-operatively by the six families, 36 acres being cropped for four years and the remaining 36 acres being rested as grazing for their cattle. After four years there would be a change over, the ploughed or cropped area would be rested and the rested area cropped.

The allottee's cottage, cattle shed, poultry house, compost pits, &c., are situated on the homestead. The block is utilized as follows :—½ acre under Java kapok. ¼ acre under banana and ¼ acre under vegetables ; bananas and vegetables to be rotated once in four years. The remaining area is planted with fruit trees and inter-cropped until the fruit trees bear. The boundaries of each homestead are separated by live fences of Murunga and Katurumurunga plants.

Each allottee works his homestead on an individual basis and is personally entitled to the product of his labour. He can dispose of his produce according to his own wishes if he so desires. This system has the advantage of combining the co-operative and individualistic elements.

Each unit elects its own leader or *gamarala* once a year before the commencement of the *maha* season. The leader guides the members of his unit, maintains check lists of labour and records of produce harvested, and settles as far as possible petty quarrels and disputes among the members of his unit. He represents his unit as a member of the working committee of the society. He is advised and guided by the resident Agricultural Instructor who is the manager of the scheme. He is paid a bonus of 1 per cent. from the gross income of each member of the particular unit for services rendred.

Two co-operative societies were formed, one at each centre in 1952. These were not registered until all the allotments were occupied and the population became static after the departure and expulsion of those who were ill-fitted to the task. In September 1952 the two societies were registered as (1) Kurundankulama Dry Farming and Sales Society Limited, and (2) Relapanawa Dry Farming and Sales Society, Limited.

The resident Agricultural Instructor who is the manager of the scheme functions as President and Treasurer of the

Co-operative and Sales Society at each centre. Each co-operative Society maintains a provision store for the benefit of its members who are given credit facilities up to a fixed limit. This has prevented them from falling into the clutches of local traders.

Every allottee is a member of the Co-operative Society. Every member has to cultivate the allotments in accordance with the planned programme and rotation laid down by the dry famring authorities. They have to conform strictly to all the regulations laid down by the Land Commissioner in allotting land to them. Any livestock issued by Government to the Society is in turn loaned by the Society to its members. No member is allowed to maintain more than 6 head of cattle and goats and a flock of poultry. All progeny raised from such foundation stock will be the property of the member who raised such progeny. All the produce from the co-operative units and preferably from the individual homestead allotments as well are to be disposed of through the Society.

It is the duty of every group of members of a unit to maintain in proper order and in good condition all roads, drains, avenues, fences, pasture blocks, wind belts farm tanks and ponds. Whenever the members have failed to attend to these, the Society will, after due warning, execute this work by engaging outside labour. Such expenditure will be deducted from the particular group.

If through the negligence of the members any damage is caused by fire or cattle to crops or property such members will be liable to pay as decided upon by the committee the cost of the damage to the particular unit or the individual member concerned.

The Society maintains and controls all issues made by Government such as draught bulls, cows and other livestock, carts, seed drills, intercultivators, ploughs, disc harrows, &c. These are in turn loaned or issued by the Society to each unit or member for specified periods of work, in some cases on hire, as may be decided by the working committee.

Each member has to maintain in good order his cottage and his cattle shed. Where a member fails to do this, the necessary repairs will be effected by the Society and the cost charged to his individual account. All the general buildings will eventually be maintained in good condition by the Society.

No member is expected to be away from his allotment at any one time without informing the leader. Before leaving his homestead he has to make adaquate arrangements with the leader for the proper care and maintenance of his livestock and house. The leader in turn informs the President. The leader cannot absent himself without informing the President.

The standard of cultivation will be done to the satisfaction of the dry farming authorities. Any allottee or group of allottees that fail to maintain a good standard of cultivation or are found to be indifferent farmers or violates or attempts to violate any of the conditions of the permit or any instructions given by the dry farming authorities will have the permit cancelled and the allottees will be compelled to quit their allotments and leave the settlement altogether. No such allottee will have right to claim any compensation from the state on any grounds whatsoever.

Every member has to pay a land tax at the rate of Rs. 10 per acre per annum for every acre under cultivation.

The work of the farm is normally performed by the members of the society, while assistance is only resorted to when it is necessary to call in hired labour to supplement the full labour strength of the Society during rush work.

The President maintains a check roll showing the labour turn out of every member. At the end of the season a complete statement showing the labour days earned by each member is posted for two weeks at the President's Office before the day of the general meeting at which the distribution of the income of the farm is to be decided.

The division of the income is done strictly *pro rata* according to the labour units earned. In deciding labour units a man is reckoned as 1 unit, a woman $\frac{3}{4}$ unit, a boy or girl between 16 and 18 years as $\frac{3}{4}$ unit and a child between 14 and 16 years as $\frac{1}{2}$ unit. All the harvested produce from each co-operative unit is handed over to the Society stores. These are valued and the price to be paid per labour unit is arrived at. Each member is then paid after making the following deductions :—

1. Land tax.
2. Payment of any cash loans, seed loans, work hired out by implements and machinery and for any other work done by the society on behalf of the member ; foodstuffs supplied on credit by the co-operative stores.
3. Payment of 1 per cent. of the gross income as bonus to the leader of the Unit for services rendered.
4. A deduction of 2 per cent. of the gross income for a reserve fund; the cash being deposited in the Co-operative Bank and used as an assurance against crop failures, &c. This reserve fund is indivisible.

Observations

1. The variability of the rainfall and its distribution during the growing season of the crops over the last five years has been very striking. The 1951-52 *maha* season was a good one for dry farmers, but the unmarried farm school students proved ill-fitted for this type of strenuous work with the result that 22 out of 39 left the scheme. Their vacancies were filled with landless peasants. The *maha* season of 1952-53 proved to be disappointing ; only 16.68 inches of rain were recorded. The rainfall was inadequate both for rainfed crops and highland crops. Frustrated over the low incomes obtained during the year a number of new settlers including 10 farm school students left the scheme. In the *maha* of 1953-54 there was a more equitable distribution of rain which was quite favourable for highland crops but woefully insufficient for rainfed paddy. The unprecedented heavy downpours in March damaged the crops and interupted harvesting and processing operations. The fourth season, 1954-55, was very favourable for rainfed paddy, which forms about 20 per cent. of the total cultivable extent in dry farming schemes, but was far too wet for highland crops and vegetables.

2. Newly recruited settlers had to be trained in farming from the very inception. Ploughing with the ceres plough and inter-row cultivation with bullock drawn implements were new to them. It takes a couple of years for them to understand the importance and usefulness of improved methods of cultivation.

3. In the absence of bullock operated automatic seed drills, the only other alternative for the settlers has been to broadcast the seeds of the different crops. Weed control in broadcasted crops presents the greatest problem. The use of weedicides for crops other than cereals cannot be considered. There is not the slightest doubt that good yields from rainfed paddy and from other highland crops can be obtained if the seed can be drilled in rows and intercultivated.

4. One of the greatest difficulties and obstacles experienced by settlers of all the schemes for raising successful crops is the severe damage caused by roaming herds of stray cattle and occasionally by wild animals. There are instances of carefully tended nurseries or well developed crops being completely destroyed overnight. It is no exaggeration to state that about 30 per cent. of the crops cultivated in the North-Central Province are destroyed by stray cattle. The cattle trespass ordinance appears to be out-dated and needs thorough revision. It is practically impossible for the occupier of a cultivated land to seize herds of stray cattle, though in theory it sounds feasible. Villagers maintain herds of cattle irrespective of the carrying capacity of the land they own. The existing system encourages promiscous breeding of unthrifty and useless cattle and encourages cattle lifting. Strict measures have to be adopted to overcome this nuisance. It is most undesirable to allow stray cattle to interfere with crop production. In no other progressive country is this allowed. We are yet primitive in this respect.

The settlers of all the schemes have dropped cotton from the rotation as this crop has proved to be unremunerative. The most popular crops are rainfed paddy, millets, chillies, bombay cowpea, groundnuts and gingelly. Traditional *chena* crops like kurakkan, kollu, black gram and green gram are not much in demand. Turdhal, lima beans, soya beans can be successfully cultivated but a demand for these has to be created. In the case of Turdhal a simple machine for processing and preparation of the dhal for market has yet to be evolved.

Considerable experience has been gained in co-operative dry farming during the last few years. The joint co-operative farming system has been very successful in units where the members were recruited from one village or where the members were from a homogenous group. In the case of some of the groups where the members were recruited from different districts their joint efforts were not up to expectations. In such cases, when persuasive measures did not have the desired effect, the rules and regulations of the society were strictly enforced, often necessitating the expulsion of the slackers. The selection of settlers for the vacant allotments has now been entrusted to the working committee of the Society.

One important problem that had to be solved was to provide some sort of occupation or employment for the settlers during the *yala* season after the sowing of their gingelly crop. In the absence of any productive work in the settlement

they have had to seek work elsewhere. This problem has now been solved with the magnificient gift of sprinkler irrigation outfits by the Canadian Government under the Colombo Plan.

Although animal husbandry has been woven into a plan of arable farming, a sufficiently attractive and steady income has not been realised from the sale of milk, owing to the small number of cows maintained and due to the absence of well managed pastures. The present production of milk is about 5,300 gallons at Kurundankulama and 3,200 gallons at Relapanawa per annum. Attempts to pursuade the settlers to plant pasture grass have not met with success, not due to their indifference, but to their inability to do this as they are invariably fully occupied with the cultivation of their crops during the rainy season. With a view to ensure the settlers of a more steady income it is proposed to pay more emphasis in future to the development of animal husbandry, particularly the production of milk.

Olukaranda

This dry farming scheme is situated three miles from Kekirawa, near the 61st mile on the Kekirawa-Anuradhapura Road. The land selected was an abandoned village named Rattagala Halmillewe, adjoining Olukaranda Village in Kalagampalatha of Nuwara Kalavia in the North-Central Province. The attraction of this site apart from the favourable situation was the presence of two big wells constructed by the military during the last world war.

About 100 acres were cleared and developed in 1950. An abandoned tank within the area was restored and deepened and about four acres of land below this tank was *asweddumised* for paddy. In addition about 8 acres of low-lying land was developed for rainfed paddy. Five cottages were constructed and a well for domestic purposes built. Three peasant families from Ehalagama Village in North-Central Province and two from the Central Province who had migrated to the North-Central Province were settled, forming a population of 44 individuals including children.

The same system of joint co-operative farming on the same extents of land per settler as in the two major schemes was introduced.

In 1952 two more families were settled bringing the total to seven. A Co-operative Credit Society was registered in 1952 to provide credit facilities to the settlers in the form of cultivation loans, &c., and thus free them from exploitation by local traders. In 1953 a centrifugal pump driven by an engine was installed for purpose of vegetable cultivation during the *yala* season by lift irrigation.

Out of the three families recruited from Ehalagama Village in the North-Central Province two families had mortgaged their paddy fields and whatever they had for various reasons when they joined the scheme. After the second year they were able to redeem their mort-

gages and also save sufficiently to start on their own. They prepared to return to their village and cultivate their fields. The third family was expelled for laziness. Three families were recruited to fill these vacancies.

Makalanagama

This scheme is situated 2½ miles from Galgamuwa on the Ehetuwawa Road in Wanni Hattpattu in the North-Western Province.

The land, about 300 acres in extent, was cleared for food production purposes during the second world war and subsequently utilised for a Co-operative Dry Farming Scheme. The purpose of the scheme was to test the possibilities of co-operative mixed farming with settlers recruited from already existing villages. The scheme was started by the writer when he was in charge of the North-Western Division. Before the scheme was fully developed and the settlers recruited the writer left the division on transfer. The scheme, thereafter, underwent a series of transitional periods till finally it was handed to the Dry Farming Division in 1952. Since this Division took over the scheme, two farm tanks within the scheme have been constructed and two existing ones repaired and bunds raised; the extent of paddy field under these tanks has been extended to 24 acres. Indifferent and lazy settlers were expelled and the vacancies filled with landless peasants from the Central Province. A Co-operative Production and Sales Society has been registered for the scheme. Eight more cottages are under construction and by the end of the year the number of settlers will be increased from 14 to 22. The system of cultivation and the extent of land given to each settler is on the same lines as in the other schemes.

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KURUNDANKULAMA SCHEME—EACH SETTLER'S INCOME

Year	1	2	3	4	5	6	7	8	9	10
	Rs. c.	Rs. c.	Rs. c.	Rs. c.	Rs. c.	Rs. c.	Rs. c.	Rs. c.	Rs. c.	Rs. c.
1938–39 ..	158 59	160 91	103 66	270 95	146 3	249 88	222 68	188 88	182 75	168 66
1939–40 ..	142 29	159 39	226 98	224 52	245 93	142 49	172 75	115 37	223 50	198 86
1940–41 ..	407 29	436 40	225 69	209 1	297 15	408 16	345 36	138 55	368 94	381 56
1941–42 ..	688 43	1,145 35	1,029 5	757 55	795 87	393 86	708 59	623 96	653 4	741 99
1942–43 ..	1,692 2	2,240 70	1,609 12	1,509 80	1,333 84	1,142 52	1,356 43	1,346 15	1,245 17	1,476 15
1943–44 ..	1,096 45	1,057 11	650 40	393 56	625 45	660 18	1,249 35	1,147 96	1,046 25	626 45
1944–45 ..	1,310 0	1,158 0	685 0	175 0	418 0	483 0	1,175 0	854 0	1,500 0	1,045 0
1945–46 ..	Vacant	1,740 0	378 0	110 0	409 0	275 0	454 0	1,036 0	1,535 0	300 0
1946–47 ..	Vacant	536 0	380 0	622 0	120 0	212 0	472 0	1,008 0	1,131 0	668 0
1947–48 ..	Vacant	1,142 98	383 0	645 10	425 80	913 0	474 64	1,121 46	1,338 24	301 30
1948–49 ..	1,317 0	1,383 50	823 25	985 37	843 50	648 70	568 50	1,641 27	1,313 79	677 0
1949–50 ..	1,018 70	896 25	726 20	518 5	452 80	645 0	1,031 30	1,093 25	1,049 30	—
1950–51 ..	719 63	1,070 83	970 5	1,213 58	1,371 38	1,063 23	845 18	798 28	819 38	728 38
1951–52* ..	909 83	1,232 26	1,094 84	1,394 40	2,122 82	2,084 96	1,425 30	1,488 62	1,437 29	1,478 77

* These settlers commenced farming co-operatively from 1951. *Note.*—The incomes stated above are exclusive of produce consumed by the settlers.

KURUNDANKULAMA SCHEME—CO-OPERATIVE UNIT No. 3

Settlers Farmed Co-operatively since 1948-49 onwards

Year	1	2	3	4	5	6
	Rs. c.	Rs. c.	Rs. c.	Rs. c.	Rs. c.	Rs. c.
1948–49 ..	1,137 36	1,119 61	1,113 50	1,086 16	1,172 69	1,135 93
1949–50 ..	1,898 80	1,487 20	1,205 0	1,288 0	1,225 0	1,326 0
1950–51 ..	2,065 0	1,553 42	1,413 72	1,313 0	1,465 0	1,487 0
1951–52 ..	1,941 26	2,051 81	1,720 17	1,772 72	2,031 97	2,084 17

Note—The incomes stated above are exclusive of produce consumed by the settlers.

KURUNDANKULAMA SCHEME

Income obtained by the new settlers who commenced farming from Maha 1951–52 onwards

Unit No.	*Colonist No.*	*Total Income*	*Remarks*
4	17	—	Occupied only in February, 1952
4	18	92 50	
4	19	99 12	
4	20	101 70	
5	21	304 86	Low income due to apathy and neglect of the colonist
5	22	285 90	
5	23	294 1	
5	24	297 26	
5	25	266 32	
6	26	139 60	Colonist came in February and in March, 1952
6	27	224 50	
6	28	267 10	
6	29	35 60	
6	30	56 0	
7	31	333 52	Low income due to insufficient attention by the colonists
7	32	262 46	
7	33	298 74	
7	34	439 98	
7	35	367 27	
8	36	304 84	Certain amount of damage by stray cattle and elephants, and want of attention
8	37	580 4	
8	38	589 26	
8	39	508 67	
8	40	499 42	
8	41	606 3	
9	42	597 2	Damage caused by wild animals and birds for want of attention
9	43	612 82	
9	44	574 87	
9	45	589 94	
9	46	572 42	
10	47	455 12	Insufficient attention by colonists
10	48	406 32	
10	49	411 42	
10	50	446 12	
10	51	426 2	
11	52	451 77	Colonists came in March
11	53	357 41	
11	54	388 99	
11	55	165 94	
11	56	153 55	

RELAPANAWA DRY FARMING SCHEME

Unit No.	*Colonist No.*	*Total Income*	*Remarks*
1	1	165 55	Allotments 3-6 were vacant until March 15, 1952. As the sowing and harvesting in these were done on Government Account. The Co-op. Block income of Rs. 1,055·82 was credited to revenue. Colonists No. 1 and 2 left the scheme before the *yala* season
1	2	263 73	
1	3	151 97½	
1	4	183 57½	
1	5	199 17½	
1	6	171 27½	
2	7	608 84	
2	8	574 26	
2	9	550 86	
2	10	546 48	
3	12	724 52½	Failure of crops due to indifference of student colonists
3	13	858 40½	
3	14	858 40½	
3	15	317 21½	
3	16	1,101 7½	
3	17	614 53½	
3	18	423 71½	Failure of crops due to indifference of student colonists
3	19	304 85½	
3	20	244 55	
4	21	343 63	
4	22	472 2	
4	23	529 80	
4	24	490 7	
4	25	414 23	
5	26	423 68	
5	27	389 73	
5	28	450 45	
5	29	972 5	
5	30	536 59	
6	31	594 40	Low yield in *yala* due to water logging in the black soil area
6	32	423 84	
6	33	372 3	
6	34	306 95	
6	35	290 57	
7	36	363 20	Low yield in *yala* due to water logging in the black soil area
7	37	332 58	
7	38	353 89	
7	39	135 74	
7	40	63 10	

OLUKARANDA SCHEME

Settler No.	*1950–51* Rs. c.	*1951–52* Rs. c.	*1952–53* Rs. c.	*1953–54* Rs. c.	*1954–55* Rs. c.
1	1,375 78	1,246 28	902 18	579 65	903 98
2	1,388 14	1,589 22	1,516 10	1,313 6	1,591 23
3	1,337 2	1,348 43	974 24	812 54	1,268 99
4	1,424 1	1,459 1	1,097 11	314 10	765 2
5	1,216 73	1,078 44	795 64	792 29	903 69
6	—	—	718 16	793 28	1,180 73
7	—	—	1,049 71	851 28	1,233 73

The Progress of Recent Breeding Work on Cotton in Ceylon

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Introduction

The history of cotton cultivation in Ceylon and the advances in the improvement of this crop up to the year 1952 have been reported by Chandraratna (1) and Fernando (2). The programme of cotton improvement initiated by these workers was continued at the Hambantota Cotton Research Station. The present paper deals with the progress made in the next four years.

The strain *BP 79*, selected in Ceylon from the variety known by the same name introduced from Uganda in 1940, was recommended for cultivation in Ceylon in 1944. The release of this variety gave a fillip to cotton cultivation in this country and the acreage under the crop increased by leaps and bounds. Arrangements were made for the purchase of the entire production in Ceylon by the Wellawatta Spinning and Weaving Mills at fixed prices. The standard requirements of the Mills were Ugandas capable of spinning a minimum of 40 counts and having a staple length of 11/8 in. The mills were satisfied with the variety *BP 79* in respect of these requirements, but after some time they complained that it was neppy.

Neppiness is the term used to describe the presence of small knots or neps of fibre on the yarn. There are two common types of nep, viz.: "tangled nep" caused by a small knot of immature fibres and "seed coat nep" also caused by a small knot of fibre, often immature, but attached to a fragment of seed coat. These fragments come from the chalazal end of the seed, where a point of weakness—caused by the larger inter-cellular spaces in the sub-epidermal layers—appears to exist (3 & 4). The neppiness in *BP 79* is mainly of the latter type.

Other introduced varieties of medium-staple cottons were tested against *BP 79* and it was found that some of them were better yielders. It was therefore considered desirable to initiate a breeding programme, to include both selection and hybridization, in order to envolve a better strain than *BP 79*. This programme gave due recognition to all the desirable characters which are deemed necessary in a good variety of cotton. Special care was taken to reduce neppiness.

Straight Selection

One of the main objectives in the selection work being improvement of quality, the pureline method of selection was adopted. A careful watch, however, was kept on such characters as ginning percentage, halo length, lint index and yield at every stage of selection.

1. Selection in 5143C, 5143C × 5143 and Co.4. Selection on three of the Upland medium-staple varieties viz.: *543 × Cambodia, 5143 Cambodia × 5143 & Co. 4* was commenced in *maha* 1949/50. The first two varieties were introduced to Ceylon from S. Africa in 1940. *Co. 4* was introduced from India in 1941. Up to the time of commencement of selection, these varieties were acclimatized and the purity maintained in the Hambantota District.

Picking cotton — Variety B. P. 79

A large number of single plant selections were made in the purity blocks in each of these varieties in *maha* 1949/50 and selfed seed was collected. On the basis of the number of fruiting branches, number of bolls, and ginning percentage the number of selections was reduced to :—

5 1 4 3 C	..	129 selections
5 1 4 3 C × 5 1 4 3	..	142 ,,
Co. 4	..	91 ,,

These selections were grown in progeny rows in *maha*, 1950/51 and on the basis of number of bolls, yield and halo length, the following were selected for further testing :—

5 1 4 3 C	..	50 selections
5 1 4 3 C × 5 1 4 3	..	47 ,,
Co. 4	..	25 ,,

Further progress in selection could not be achieved in *maha* 1951/52 on account of adverse weather conditions. It was only possible to maintain most of them.

In *maha* 1952/53, the selections in each variety were set down in separate replicated yield trials. The randomised block design was used with single row plots 50 ft. long. Control plots of the parent variety (i.e., selfed seed from the maintenance of purity block of each variety) were set down at regular 5-row intervals. Further selection was based, in addition to yield, on the standards given below. The number of selections retained is also shown in the table below.

The lint from these selections was sent to the Shirley Institute, Manchester, for small-scale spinning test and a summary of the remarks made by the Institute is given below—

" Selections from the variety *5143C* gave yarns weaker and of poorer appearance than those from the variety *Co. 4*, although the yarns from the *5143C* selections did not contain quite so much nep as those from *Co. 4* selections. There was a wide range of spinning quality in the samples from the *5143C* × *5143* selections. The strength of the yarns spun from the *Co. 4* selections was on the whole satisfactory. In the yarns of fair and moderate appearance (*Co. 4*) there was a considerable amount of nep, most of which appeared to be seed coat fragments ".

The new strains thus obtained in each variety were tested in three separate yield trials with *BP 79* as control in *maha* 1953/54. The results did not reach

Variety	*Halo Length*	*Ginning%*	*Lint Index*	*No. of Selections retained*
5143 C ..	30·0mm & over ..	30·8% & over ..	0·14 & over ..	8
5143 C × 5143 ..	31·4 ,, ..	29·2% ,, ..	0·17 ,, ..	7
Co. 4 ..	30·0 ,, ..	27·8% ,, ..	0·14 ,, ..	5

the level of significance on account of adverse weather conditions during the growing period. All the strains selected from the three varieties were carried over and set down in a combined replicated yield trial against the parent varieties and *BP 79* in *maha* 1954/55. The results are given in Table I. The selections marked with asterisks significantly out-yielded their respective parent varieties at the 1 per cent. point. Thirteen out of the 20 selections tested yielded significantly higher than *BP 79*.

Large-scale spinning tests were carried out with the best selection in each of the varieties and with *BP 79* at the Shirley Institute. The report from the Institute is reproduced in Table II.

Table I

Selections	*Yield in cwt./ acre*	*% of BP 79*
5143C		
S 1—44	11·40	163·5
S 2—36	12·66	181·6
S 3—14	11·27	163·1
*S 4—39	17·55	251·7
S 5—43	11·87	170·3
*S 6—06	19·88	285·2
S 7—19	11·68	167·5
S 8—02	13·95	200·1
Parent Variety (5143C)	10·45	149·8
5143C × 5143		
*S 10—18	15·35	220·2
S 11—44	9·88	141·7
S 12—34	11·41	163·7
S 13—35	11·94	171·3
S 14—21	10·42	149·4
S 15—05	9·55	137·0
S 16—20	10·53	151·0
Parent Variety (5143C × 5143)	8·30	119·0
Co. 4		
S 19—18	12·27	176·0
S 20—17	9·02	129·4
S 21—14	12·30	176·4
S 22—03	7·86	112·7
S 23—05	10·42	148·4
Parent Variety (Co. 4)	8·77	125·8
BP 79	6·97	100·0
Standard Error		14·2
Significant Difference (P = 0·01)		52·4

Significant at the 1% point.

Table II

Variety	*Fibre Tests*					*Yarn Tests Twist Factor = 3·75*				
	Effective Length (32nds in)	*% Short Fibre*	*Maturity Ratio**	*Fibre Wt. per cm**		*Analyser % Trash*	*50s Count Corrected Lea Count × Strength Product*	*Yarn Appearance †*	*50s Count Corrected Lea Count × Strength Product*	*Yarn Appearance †*	*Highest Standard Count ‡*
				Mean	*Standard*						
BP 79	39	34	0·925	150	162	3·39	1804	7	1577	7	38
5143C × 5143	39	35	0·865	193	223	0·91	1650	6	1328	5	35
5143C	42	35	0·860	149	173	0·96	1918	5	1705	4	44
Co. 4	36	34	0·795	173	218	1·52	1568	6	1294	6	27

* N = % Normal fibers ; D = % Dead fibres ; Maturity ratio = $\frac{N-D}{200} + 0{\cdot}70$; Standard fibre weight = Mean fibre weight ÷ Maturity Ratio.

† Yarn appearance classification.

‡ Highest Standard Count = Count in which yarn would be expected to give a count ÷ Strength Product of 2,000 carded, 2.250 combed. This is not necessarily the highest Spinnable Count.

1. Very Good. 2. Good. 3. Fairly Good. 4. Fair. 5. Moderate. 6. Poor. 7. Very Poor.

5143C selection No. S6-06 was the longest and spun the strongest yarns. *5143C* × *5143* selection No. S 10–18 was similar in length to *BP 79* but considerably coarser. It spun rather weaker yarns. *Co. 4* selection No. S 21–14 was the shortest sample; the yarns from this sample were the weakest. The yarns from the *BP 79* sample were very poor in appearance largely owing to seed coat nep. None of the samples gave yarns free from nep, but those from *5143C* were the best in this respect.

While the spinning tests were being carried out at the Shirley Institute, the usual laboratory tests were performed with all the selections, and the highest yielding strains of each variety which conformed to the following standards were retained :—

Lint Index	..	0·17 and over
Ginning%	..	30·0 ,,
Halo Length	..	30mm. ,,

These strains which consisted of three from *5143C* 3 from *5143C* × *5143* and two from *Co. 4* were tested in a final yield trial with the parent varieties as controls in *maha* 1955/56.

The results confirmed those of the previous season. The selection S 6-06, S 10-18 and S 19-18 were the highest yielders in the varieties *5143C*, *5143C* × *5143* and *Co. 4* respectively. The best selection in *5143C* outyielded all other selections. Ginning tests carried out with these selections gave the following figures :—

Variety	*Ginning Percentage*
5143C	33·8
5143C × 5143 ..	33·8
Co. 4	30·5
BP 79	28·7

2. **Selection in Mwanza 561, Mwanza Local, BP 52, Co. 2 & Co. 3.** Selection work was also commenced in the above five Upland medium-staple varieties in *maha* 1951/52. The *Mwanza* varieties were introduced from Tanganyika in 1940, *BP 52* from Uganda in the same year, and *Co. 2* and *Co. 3* from India in 1937 and 1941 respectively.

These varieties were also acclimatized in the Hambantota District before selection work was commenced. The selection procedure adopted was very similar to that described earlier. The number of strains retained at each stage of selection is given in the schedule below :—

	M 561	*ML*	*BP 52*	*Co. 2*	*Co. 3*
MAHA 51-52 ..	22 ..	32 ..	11 ..	3 ..	18
,, 52–53 ..	8 ..	11 ..	3 ..	3 ..	5
,, 53-54 ..	8 ..	11 ..	3 ..	2 ..	5
,, 54–55 ..	5 ..	3 ..	0 ..	0 ..	3

The selections in *BP 52* and *Co. 2* were rejected at the end of *maha* 54/55 as they did not reach the required standards in respect of lint index, ginning percentage and halo length.

In *maha* 1955/56 separate yield trials were conducted with the selections in the three remaining varieties against the original unselected materials. The yield figures are given in Table III.

Table III

Selections	*Yield in Cwt./ Acre*	*% of Parent Variety*
M 561		
Selection No. S—12 ..	6·06	106·9
S—15 ..	6·62	116·8
S—16 ..	7·42	130·9
S—17 ..	8·13	143·4
S—18 ..	5·43	95·8
Parent Variety (M 561)	5·67	100·0
M. L.		
Selection No. S—27 ..	7·19	113·7
S—28 ..	8·06	127·5
S—31 ..	7·59	120·1
Parent Variety (M. L.)	6·32	100·0
Co. 3		
Selection No. S—6 ..	9·63	110·7
S—7 ..	7·38	84·8
S—10 ..	8·48	97·5
Parent Variety (Co. 3)	8·70	100·0

Lint from the best selections in these varieties have been sent to the Shirley Institute for comprehensive spinning tests.

It is useful, at this stage, to consider the methods adopted in breeding for reduction of "seed coat neps". The removal of the chalazal cap during ginning (which causes the seed coat neps in the yarns) leaves a bare spot on the seed which can be easily seen on examination of the ginned seed. It is therefore possible to estimate the proneness of any variety to seed coat nep by determining the percentage of seeds showing chalazal cap removal in ginning (3). This technique is, now, proving useful in breeding work against seed coat neppiness. Investigations made at the Shirley Institute have shown that the relation between percent damaged seed and yarn appearance was generally close (5). Apart from the percentage of seeds damaged, the number of seed coat neps in the sample will also depend on the number of seeds per unit weight of lint. Breeding for high lint index is therefore a step in the right direction towards reducing seed coat nep, for of two cottons with the same seed damage count the one with the higher lint index (fewer seeds per unit weight of lint) should produce the less neppy yarn (5).

High lint index has always been an important objective in the breeding work done in Ceylon. The estimation of seed damage count is being done at present.

Cross-pollinating Cotton by hand

Wirawila Cotton Station

Hybridization

An ambitious hybridization project in cotton was commenced in *maha* 1952/53 with 33 crosses. The aim of this project was to evolve superior strains with the following characters :—

1. High yield.
2. Staple length between $1\frac{1}{8}$-$1\frac{1}{4}$ in.
3. Ginning percentage over 30%.
4. Lint index over 0.17.
5. Lint free of nep.
6. Good spinning qualities.
7. High oil content of seed.

This programme consisted of crossing groups of unrelated varieties introduced from different countries. These groups were : *Mwanzas* from Tanganyika, *Co.* varieties from India, *Domain Sakel* from Sudan, *Cambodia* varieties from S. Africa and *BP* varieties from Uganda.

The crosses effected were—

5143 Cambodia × Mwanza Local
× Domain Sakel
× S. G. 29
× B. P. 52
× B. P. 79
× Mwanza 561

S. G. 29 × Mwanza 561
× Co. 2

Mwanza Local × B. P. 52
× Co. 2
× Domain Sakel

Co. 3 × B. P. 79
× Domain Sakel
× Mwanza Local
× Mwanza 561
× B. P. 52

Co. 2 × Domain Sakel
× Mwanza 561

Co. 4 × B. P. 52
× Mwanza Local
× Domain Sakel
× Mwanza 561

B. P. 79 × 5143 Cambodia
× Co. 4
× Mwanza Local
× 5143 Cambodia × 5143
× Mwanza 561
× Co. 2

5143 Cambodia × 5143
× Domain Sakel
× Mwanza Local
× Mwanza 561
× B. P. 52

Domain Sakel × Mwanza 561

The pedigree method of hybrid selection was adopted. Individual plant selection was commenced in the F2 generation of each cross and these were carried into progeny rows in F3. The questionable lines were eliminated ; and within the desired progeny rows two to three individual plants were selected and selfed. In the following season the selections, which were in the F4 generation, were grown in unreplicated compact family blocks. Sufficient uniformity was observed within the progeny rows and even between progeny rows within a family. However, promising progency rows were selected and as many flowers as possible were selfed within the selected progeny rows. Laboratory tests have been carried out on the selected rows. Sub-standard strains will be rejected and the balance will be tested in replicated yield trials in F5. The results so far indicate that suitable strains which combine most of the desired characters could be obtained.

Scheme of Seed Production

The procedure adopted regarding the maintenance of purity of *BP 79* and the multiplication of seed for issue to cultivators has been described in detail by Fernando (2). To state very briefly, the methods followed were Harland's Mass Pedigree System of maintenance and the subsequent multiplication in isolation under open-pollinated conditions at Wirawila Cotton Station. This scheme of seed production has not proved very satisfactory due to various reasons, chief among which are the generally low

yields obtained at Wirawila, and occasional crop failure due to unfavourable seasons.

A new scheme of seed production has now been envisaged. The purity maintenance will be in a two-acre block at the Tissa Paddy and Cotton Research Station. Multiplication of pure seed in the first stage will be at Wirawila Cotton Station and Bata-ata Agricultural Station in 20-acre blocks at each station. This ensures reasonable seed multiplication in the first stage, even in the event of crop failure at one station.

With a minimum average yield of 2 cwt./acre of seed cotton at these two stations, the seed produced will be sufficient to grow 400 acres of purity cotton at the maximum seed rate of 15 lb./acre. These 400 acres will be grown in the second stage of seed multiplication at Pelwehera, Maha Illuppallama and a selected village in the Hambantota District. The isolated Gonnoruwa cotton-growing village, where a fairly high standard of cultivation is practised and where yields more than the average are obtained, would be suitable for this purpose. The seed produced at these three centres should be sufficient to meet the Island's requirements of cotton seed.

Replacement of BP 79

The defects in *BP 79*, the cotton exclusively grown in Ceylon at present, have been mentioned earlier. In view of the superior strains now available, it was considered desirable to replace *BP 79* with one of the new selections. The *5143 Cambodia* selection S6-06 has proved to be superior to others at every stage of testing. It out-yielded all other selections ; the staple length of 42/32 in. was extremely satisfactory ; its ginning percentage was 33.8 ; it spun the strongest yarns and had the best yarn appearance, especially in respect of neppines. Sufficient quantity of lint for a commercial spinning test was available only at the end of the *maha* 1955/56 season. The commercial spinning test was carried out at the Wellawatte Spinning and Weaving Mills and the report is given below—

Cotton :—

Colour ..	.. White
Cleanliness	.. Fair
Feel ..	.. Smooth
Card Sliver	.. Clean
Card Web	.. A little Neppy

Yarn :—

Cleanliness	.. Clean
Evenness ..	.. Even
Neppiness	.. A little neppy

Losses :—

Blowroom	.. 4%
Card ..	.. 6%
Speed frame and ring	.. 3%

Count × Strength Product :—

40s Warp ..	.. 1811
50s Warp ..	.. 1655
60s Warp ..	.. 1508

The report is, on the whole, very satisfactory. The *5143 Cambodia* selection was as good as the best lint imported by the mills in respect of neppiness and pre-spinning losses. The test proved beyond doubt that this selection was far superior to *BP 79* in all respects. *BP 79* was used in the mills only for spinning 20S and 30S counts, whereas the new selection is capable of spinning 40S and 50S counts. This coupled with the higher ginning percentage of this selection, enhances its value and the growers could expect a higher price for the seed cotton of this variety.

It has, therefore, been decided to announce this selection as *HC 101* (Hambantota Cotton 101) and issue it for general cultivation in Ceylon. It is now in the first stage of multiplication and it is expected to completely replace *BP 79* in 1958.

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Techniques of Seed and Seedling Production with Sugar Cane

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Historical

Although the history of sugar cane stretches far into the distant past, cane breeding is comparatively recent. The earliest mention of sugar cane is in legends concerning the Buddha about the fourth century B. C., and it is generally agreed that one of the centres of origin of cane is Northern India. From India it is believed to have been first carried to China probably via Assam. The Chinese then carried it to Formosa, Java and the Philipines. While in the earliest times the cultivation of cane was as a garden crop and its use restricted to the chewing of the stalks and drinking of the juice, the manufacture of sugar from cane was an established industry at the time of the advent of Europeans into this area. In the other direction, the Arabs introduced the cane into Southern Europe and North Africa. Columbus carried the cane thence to Santa Domingo on his second voyage in 1494. From Santa Domingo it spread to North and South America, Cuba and the West Indies.

There was then in the 19th Century a flourishing sugar industry spread generally along the equatorial belt. Naturally the number of varieties cultivated were few, and up to this time little need was felt for diversity since the existing varieties were apparently thriving and the manufactured sugar was fetching favourable prices in the market.

Danger signals began to appear about the middle of the 19th Century. About 1840, in Mauritius and Reunion, the predominant variety, Otaheite was affected by a disease which assumed epidemic proportions and threatened the entire industry there. The exact nature of the disease is unknown, but the epidemic was interpreted as a "degeneration" of the variety. Next, in 1860, disease in epidemic form threatened the industry in Brazil, and in 1872 disease appeared in Puerto Rico. In both these instances too, the variety affected was Otaheite. In every instance, the remedial measures adopted were the introduction of varieties from abroad and the testing of them for resistance to the prevalent disease.

Since the cane is normally propagated vegetatively, it was generally believed the plant had lost its capacity to produce viable seed. The degree of conviction with which this idea was held at the time is evident from the fact that a committee appointed by the Hawaiian Agricultural Society in 1851 to investigate the possibility of producing new varieties by hybridisation, reported in 1854 that seedling production was not possible. Further, a claim made by A. W. Parris of Barbados in 1858 to have raised some cane seedlings that appeared as volunteers in his plantation appears to have been ignored. Meantime, the inroads of disease and the threat of extinction of the industry continued.

About 1880, plantations in Java were affected by a disease later called Sereh, from the fact that affected plants became severely stunted and took the form of that grass. The immediate danger was averted by the adoption of expensive agronomic practices. However, as the danger of epidemic disease was very real and the potentialities of introducing new cane varieties were limited, the need for hybridisation was keenly felt and the study continued.

It is, therefore, not surprising that positive results were reported almost simultaneously a short time later from two quarters. In 1885, F. Soltwedel in Java after a detailed study of the cane flower reported that he saw no reason why the cane should not produce seed, and went on to produce seedlings in 1887.

In 1888, Harrison and Bowell also reported the production of seedlings from Barbados.

It should also be mentioned that although the fact that cane seedling production was possible was established *circa* 1888, the numerous problems of technique yet remained to be worked out and it was actually not until the turn of the century that systematic breeding and seedling testing got under way.

This marked the birth of a new era. Today, every major cane-growing country in the world spends considerable sums of money on breeding programmes.

In Ceylon, sugar cane has yet to attain the status of an industry. It is true that cane is cultivated in various parts of the Island. Three hundred acres are under cane in the Nagoda area on the banks of the Gin Ganga. There is a very small extent cultivated at Haldamulla and Ratnapura. There are also cane " gardens " (they cannot be called anything else) in various places. These cultivations are mainly for the purpose of producing a crude jaggery, or for sale of the stalks for chewing at festivals.

That these cultivations are of negligable extent becomes apparent when it is realised that a modern sugar factory handles cane from 8,000-10,000 acres in one season.

Systematic investigations into the possibilities of cane cultivation were commenced at Polonnaruwa in 1951. As these preliminary investigations proved a success, in 1953, a study designed to explore the potentialities of cane breeding was commenced. Results of these studies are reviewed below.

In regard to problems of technique, the following questions need study :—

1. The principles of mating.
2. Flower dehiscence and pollen discharge.
3. The technique of controlled crossing and seed production.
4. The method of seed storage.
5. Technique of germination of the seed.
6. Seedling selection.

1. Principles of Mating

It is not proposed to deal with this point at length in this paper. Breeding was born out of the threat of extinction of the industry by disease. The canes in cultivation prior to this period (the so called Noble canes) while having a high sugar status were generally susceptible to disease, while the wild varieties have little sugar but a high degree of disease resistance. The practice, therefore, has been to cross Noble vareties with " Wild " relatives and back-cross these

progenies to the Noble varieties, the process being called Nobilisation. Two wild species *Saccharum spontaneum* (of which a number of strains exist) and *Saccharum rebustum* have been used for this purpose.

In Ceylon, breeding has been limited due to (*a*) the need to perfect techniques initially, (*b*) the paucity of varieties (we are now importing a number of varieties) and (*c*) the small extent under cultivation.

It is of interest to note that a strain of *Saccharum spontaneum* has been found recently growing locally at Inginiyagalla and is now being propagated for study.

2. Flower Dehiscence and Pollen Discharge

The times of maximum flower dehiscence and the stage of pollen shedding are of fundamental importance. These points were studied over a season. All florets that had dehisced were plucked out with a fine forceps and counted in the first instance at four hour intervals. The results showed that maximum dehiscence occurred during the period 3.0 a.m. to 7.0 a.m. Following this, the number of florets which dehisced during the period 3.0 a.m.-7.0 a.m. were counted at one hour intervals. It was then found that maximum dehiscence took place during the period from 4.0-5.0 a.m. Pollen discharge was noted to follow closely on floret dehiscence.

3. Crossing Technique

Two problems arise. Firstly, the impracticability of emasculation of individual flowers and introduction of desired pollen therefater and as a consequence of this fact the need to centralise crossing as far as possible in one spot. Emasculation of the individual florets is not possible for four reasons—the minute proportions of the individual florets, the large number of florets on an inflorescence, the height at which the flowers occur (about 15-20 ft. above ground level) and the need for as large a number of seedlings as possible.

Numerous attempts have been made to induce pollen sterility as by dipping the inflorescence into warm water, &c., but the writer is not aware of any practical achievement in this field to date.

Therefore, recourse is made to the fortunate circumstance of the flower itself, that some varieties do not produce viable pollen (or produce very little) while others do so in variable profusion, female sterility being rare.

The method of determination of pollen viability is to tease out the anthers of mature flowers (those that are due to open the following day) into a dilute solution of iodine and make a count of the number of stained grains. Grains considered viable are smooth, round, firm and take a dark stain ; non viable grains are generally shrunken and do not stain. The viability is expressed as a percentage of total pollen grains after counts on several microscopic fields have been made. These figures are inevitably approximate, and are generally grouped into the following classes :—0—2, 2—5, 5—15, 15—30, 30—50 and 50+. If the percentage of viable pollen is less than 5, that variety is suitable for use as a female and if more than 30 as a male. Those varieties producing more than 5 and less than 30 per cent. viable pollen are problematic and this factor tends to

set some limit on crosses. Actually they may be used as either male or female parents though with some what unsatisfactory results. This test has to be carried out regularly since variations (the reasons for which are still obscure) occur from season to season as well as during different periods in the same season. In all the seasons tested the varieties Co 453 and Co 617 produced abundant viable pollen while Co 527 and Co 655 proved females, Co 449 being intermediate. Co 421 showed wide fluctuations of pollen viability.

Other methods of determining viability (such as germination of the pollen grains on the styles of other flowers—*Hibiscus* sp.—and in nutrient solutions) have been tried but the iodine test is the simplest and easiest and is sufficiently reliable.

The technique of crossing thereafter consists simply of bringing a pollen fertile variety up to a pollen sterile one under conditions that will avoid contamination. Since florets on an inflorescence continue to open for about two weeks, it is necessary to bring pollen to the inflorescence during that entire period. Hence the desirability of centralisation.

There are two generally accepted methods of centralisation :

1. The Hawaiian method.
2. The Indian method.

The Hawaiian Method. The inflorescence together with much of the stalk is cut and stood in a dilute solution of sulphurous acid and phosphoric acid. When this solution is changed every other day and about one inch of the bottom of the stalk cut off at that time, the inflorescence remains fresh and matures normally. It is hoped to test this method at Polonnaruwa during the coming season.

The Indian Method. The Indian method which has been successfully used at Polonnaruwa is based on the principle that the root primordia that occur at every node can be made to grow under certain conditions. Some weeks before flowering a potting mixture is wrapped round the upper part of the stalk so as to cover two or more nodes, and the mixture is kept moist. Roots develop in a very short time and before flowering the stalk is severed below these roots and the stalk transferred into a pot. The process does not interfere with emergence of the inflorescence or seed setting.

4. Seed Storage

At Polonnaruwa the cane flowers in late September-October and seed is ripe by late November-December. Planting does not commence until May of the following year. The seed, however, does not remain viable for more than a few weeks, so that a reliable means of storage becomes necessary. The standard method of seed storage has been used successfully. This consists of storing the seed in a dry atmosphere under refrigeration.

It takes 10-14 days for all the florets of an inflorescence to dehisce, and another 2-3 weeks for the seed to mature. Thereafter the entire arrows are cut, placed in cloth bags and sun dried for 2-4 days. At the end of this drying the seed (fuzz) comes freely off the stalks and can be easily collected free of stalk in the bag. For the tests at Polonnaruwa, the fuzz was now transferred

into empty bottles. A dry atmosphere being a prerequisite, about 10 gm. of calcium chloride tied in a calico square were placed in each bottle and about 20-25 grams of fuzz put in. The bottles were stoppered and the mouths sealed with paraffin wax. The bottles were then transferred to cold storage. At the end of 3 months, the bottles were opened and the seed sown in seed flats. A germination count of 500-600 seedlings was obtained per flat.

5. Seed Germination

The seed is sown on sterilised soil placed in shallow seed flats. No attempt is made to separate the seeds from the other flower parts and husks. When the flats are ready, the seed is spread evenly on the flat, settled with the hand and a fine spray of water and pressed firmly on to the soil surface. Thereafter the flats are placed in the open and moistened frequently to prevent the surface from drying out. Germination commences in about 48 hours. It is usual to apply a spray of a dilute fungicide at sowing, or in the next few days to guard against any fungal infection and subsequent death of seedlings.

6. Seedling Selection

When the seedlings are 3–4 in. tall they are transferred into nursery beds and from here, they are transplanted individually in the field.

It is not proposed to consider the details of seedling selection.

At the end of the first year the first selection of individual seedlings is done. Here all seedlings with undesirable agricultural habits are first discarded. The remaining seedlings are tested for sugar content with a hand refractometer and compared against standard varieties that are planted throughout the fields for this purpose. Those seedlings with high sugar are selected for further test.

The quantity of cane from a single plant is limited. The further process then is to multiply the selected seedlings so that sufficient planting material is available for replicated yield trials. In the meantime from the multiplication plots further study of the cane is made, now including germination, maturity testing, ratooning-capacity and disease resistance. Thus, further rejection is done until the final seedlings go into the fore-mentioned yield trials. From the germination of the seedlings, it therefore takes 7-8 years before a seedling is ready for release as a commercial variety.

In conclusion it must be stressed once again that the studies carried out at Polonnaruwa to date have been mainly in the nature of studying techniques more than anything else. Some seedlings have been produced incidentally and these have been transferred to the field for study, but the numbers so planted are comparatively small. It is hoped to embark on a more ambitious programme of seedling production in the coming year.

A Brief Survey of Agricultural Conditions in the Sabaragamuwa Province

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The Sabaragamuwa Province comprises two Revenue Districts—Kegalla and Ratnapura. The total land area is 1,211,200 acres ; of the 641,303 acres of cultivable area, 517,830 acres have been cultivated and 123,473 acres are uncultivated.

Relief

Broadly speaking, the relief of the Sabaragamuwa Province may be said to consist in the main of the southern and western edges of the central massif. The southern portion of this massif exceeds 6,000 feet, for the most part, in the Province. The slope to the west is gradual and extends mainly to the Kegalla District. It is drained by the northern tributaries of the Kelani Ganga and Maha Oya. To the south, the ridge drops precipitously through the plains of Gilimale, Bambarakotuwa and Balangoda and at the lower part it is drained by the Kalu Ganga towards the west and the Walawe Ganga to the south forming mainly the Ratnapura District. To the south of the Province lie the south-western maritime ridges which follow the trend of the coast and rise to heights of 4,000 feet at Bulutota. Both to the east as well as to the north-west there is a descent from these parallel ridges along corresponding parallel valleys to the basins of the Walawe Ganga and Kalu Ganga, the two rivers which drain the waters from the ridges in Sabaragamuwa. The southern portion of these ridges is popularly referred to as the Sinharaja Forest. As the map will show, the line of demarcation between these two ridges is the broad and comparatively flat basin of the Kalu Ganga.

Rainfall

The whole Province receives rain during the north-east monsoon and this may be said to be fairly regular, averaging 50 or more inches per annum except in the Embilipitiya region which is definitely a part of the dry zone. During the south-west monsoon the Ratnapura District receives fairly heavy rain except to the east of the Hunuwala-Bulutota axis which lies in the rain shadow. The annual rainfall is heavy in the parallel ridges as well as to the south of the central massif and varies from 150–200 inches, in view of the precipitous slope referred to above. To the north of the Adam's Peak latitude the higher portions of the central massif are far removed from the eastern ridge of the District and in view of the gradual elevation from the coast to the peaks of Pidurutalagala, viz., Hatton plateau the rainfall is more uniformly spread out, and averages for the year approximately 100 inches per annum. The average rainfall from 1911-1940 is shown in Table I.

Table I—Average Rainfall in Inches (1911–40)

	Kegalla	*Ratnapura*	*Balangoda*	*Embilipitiya*
January	4·60	6·22	6·52	4·56
February	2·72	5·25	4·64	2·98
March	7·96	10·38	9·26	7·18
April	9·59	11·55	11·15	6·55
May	10·28	20·95	9·11	4·55
June	11·22	18·58	5·98	1·60
July	7·45	12·80	4·64	1·95
August	5·89	11·39	3·35	—
September	7·94	14·57	5·45	3·34
October	16·64	17·99	10·61	8·63
November	12·97	14·81	11·63	11·34
December	7·42	9·10	10·38	7·34
Average Total for 30 years ..	104·88	153·59	92·62	60·97

Drainage

The four rivers referred to above have their principle affluence in the central massif and radiate like the sector of a circle. Three of these rivers, viz., the Maha Oya, the northern tributaries of Kelani Ganga and Walawe Ganga flow along gentle slopes in areas where the rainfall is in the neighbourhood of 100 inches per year. The Kalu Ganga and the southern tributaries of the Kelani are a contrast to these in that they flow not only through the heaviest rain-fed area in the Island but in their upper reaches flow along precipitous slopes. These steep courses aided by torrential downpours have resulted in the maximum of erosion and grading of the river in the Kalu Ganga basin and the southern Kelani. In other words after a few miles of precipitous drop the rivers flow along flat or nearly flat courses. In proof of this it could be seen that the height of the river at Ratnapura is only 85 feet above mean sea level. The grading has reached its limits and no further grading or cutting down is possible. In fact due to the vast opening of plantation agriculture in the District a reverse grading may be said to be in progress, thus accounting for the floodable lower strata which in turn is made boggy or marshy by the underlying stratum of clay. The clay referred to, is popularly known as the *Illam* or gem gravel layer which is the wash of the denuded material of the central massif according to Wadia. The wash over geological eras had deposited the clay and the gem gravel over which the subsequent alluvial deposits had spread themselves. It will thus be seen that vast tracts of this district particularly in Kukul Korale and in Kuruwiti Korale have an underlying clay base which prevents percolation thus giving rise to marshy pockets. The flow of waters during the torrential downpour has of necessity to be of a surface nature for the reasons mentioned above, viz., (*a*) a nearly fully graded course, (*b*) underlying clay strata. The marshiness of the more humid parts of the Ratnapura District may be attributed to a heavy downpour which has to flow along a flat course over an underlying stratum of clay.

Population

The population of Sabaragamuwa according to census figures in 1953 is 890.8 thousand of which 471.2 thousand are males and 419.6 thousand are females. On plantations 15.8 per cent. of the Indian population of the Island are employed. The Kandyan population is 38.9 per cent. The density increased from 136 per square mile in 1891 to 471 per square mile in 1953.

Land Tenure

Land tenure in the province has been influenced by ancient systems and local customs. European and Ceylonese capitalists have developed almost two thirds of the cultivable area with tea, rubber and coconuts—three profitable crops. The cultivation of food crops is confined to small holdings and fields in the valleys or on terraced slopes for paddy. Nearly 131,500 acres of land are owned by landlords who have inherited these, known as *Nindagamas* from their ancestors. These *Nindagama* lands are worked by tenant cultivators who pay them an annual rent. Paddy fields are generally cultivated on the share or *ande* system in which the cultivator is entitled to half or in some cases of the poorer fields two-thirds of the produce. The value of the seed paddy and also the manure is shared according to the conditions of agreement. In the apportionment of the crop, the *Vel Vidane's* share, known as *huandiran,* the quantity of seed paddy (generally borrowed from the landlord) plus 50 per cent. as interest are deducted before the 1/2 or 2/3 division. The buffaloes required for working the fields are usually procured by the tenant from the landlord who would then be entitled to receive half to three-fourth of the tenant's share of the crop in payment. The usual period of tenure is one season only. In many parts of the Province, a monetary tax known as *madaram* is levied by land owners. The sum varies according to the fertility of the fields. *Adayan* is another tax levied by landlords from their tenants to meet Government irrigation rates and this amounts to a one-fourteenth share. It is customary in many parts of the Province for tenants to perform certain services on more or less a voluntary basis, for their landlords. The *Gambaraya* is an agent of the landlord who collects the share and taxes due to the latter.

Distribution of paddy land under the various systems of land tenure is shown in Table II. The classification of paddy land according to size of holding is given in Table III.

Table II—Assweddumised Paddy Lands (exclusive of paddy lands within estates)

District	*Total No. of Holdings*	*Total Extent in Acres*	*Owner*		*Lessee*		*Ande Tenant*	
			No. of Holdings	*Extent in Acres*	*No. of Holdings*	*Extent in Acres*	*No. of Holdings*	*Extent in Acres*
Ratnapura ..	31,778 ..	33,540 ..	6,917 ..	6,428 ..	1,017 ..	1,132 ..	15,502 ..	16,822
Kegalla ..	34,253 ..	26,929 ..	11,725 ..	8,171 ..	403 ..	327 ..	9,520 ..	8,557
Total ..	66,031	60,469	18,642	14,599	1,420	1,459	25,022	25,379

Table III.— Asweddumised Paddy Lands exclusive of Paddy Lands within Estates

District	Less than ¼ Acre		¼–1 Acre		1–2 Acres		2–5 Acres		5–10 Acres		10 Acres and over	
	No. of Holdings	Extent in Acres	No. of Holdings	Extent in Acres	No. of Holdings	Extent in Acres	No. of Holdings	Extent in Acres	No. of Holdings	Extent in Acres	No. of Holdings	Extent in Acre
Ratnapura	7,015	1,688	10,713	6,521	9,842	12,366	3,866	9,942	256	1,613	80	1,408
Kegalla	9,779	2,344	14,023	8,639	8,168	10,125	2,235	5,480	43	254	5	86
Total	16,794	4,032	24,736	15,160	18,016	22,491	6,101	15,422	299	1,867	85	1,494

Soils

Soils of the Sabaragamuwa Province are lateritic or laterite in type and the top soils of the *kekilla* lands are greyish light loams with occasional decomposing rock fragments. The soils are well drained and carry good stands of forests. Owing to intense leaching, they are poor in replaceable bases and strongly acid in reaction. These types of soils are suitable for permanent crops such as rubber and tea. The paddy soils in the Kegalla District are generally light, sandy loams to heavy clays. On the average, these soils contain fair quantities of plant food constituents and are replenished by the silt from the hill slopes. Paddy areas in Kuruwita and Nawadun Korales are generally peaty with poor drainage. The *deniya* soils are low-lying, ill-drained dark grey sands of shallow depth. The subsoil is bleached and overlying kaolinitic clay. The soils are very acid in reaction and of low base exchange capacity. In the Balangoda region the soils are sandy and poor in plant nutrients. This is mainly due to leaching over a period of several years.

Land Utilization

There are 458 holdings of "A" Estates and 1,245 holdings of "B" Estates. The acreage of crops excluding towns and village gardens is 518,506 comprising—

	Acres
Tea	83,432
Rubber	246,286
Coconuts	82,290
Rice	60,571
Chena	3,669
Other cultivations	4,225

Tea

The total extent under tea is 83,432 acres. In Ratnapura 48,535 acres and in Kegalla 192,822 acres are under "A" Estates. Except for a few estates under the management of companies, the standard of cultivation is poor. In the Balangoda region, considerable erosion has taken place. Guatamala grass is now being interplanted in tea as a soil conservation measure.

Rubber

The total extent in the division is 246,286 acres of which 243,584 acres are tappable. Tapping of rubber trees in village holdings and estates varying from 5-10 acres has been very unsatisfactory and the present condition of these is poor. The Government Replanting Scheme assists small holders to replant their holdings with approved clones of high yielding rubber. Several thousands of clonal seedlings raised on Agricultural Departmental farms and the nurseries of the Rubber Research Institute are issued for replanting.

Coconuts

There are 82,290 acres under coconut in the division. Except for an extent of 2,227 acres the units are below 20 acres. In the Ratnapura District, the coconut estates are in Atakalan and Kolonne Korales. In most small holdings, coconut is grown for home consumption.

Spices

Pepper. The vines growing on about 711 acres are trained on to high shade trees in home gardens and boundary fences.

Cardamoms. There are small extents grown at the higher elevation in Balangoda and Rakwana regions where moist humus conditions and natural shade prevail. About 285 acres are grown under this crop.

Ginger and Turmeric. These crops are grown in home gardens throughout the Province mainly for home consumption. About 365 acres are under ginger and 389 under turmeric.

Papaya. This crop is grown in Atakalan Korale at an elevation of 500 feet for papain production. On account of the mild, dry climate and well drained soil this area has been found suitable for this crop. It is also grown on the hill slopes mixed with plantains. About 1,000 acres are grown under this crop.

Other crops under cultivation are shown in Table IV.

Table IV—Food Crops cultivated on Highlands

Crop	*Maha 1952–53* *Acres*	*Yields* *Bushels*	*Yala 1953* *Acres*	*Yields* *Bushels*
Kurakkan	5,283	55,547	5,168	48,769
Maize	1,395	9,720	1,257	10,847
Mineri	529	2,925	445	2,846
Gingelly	294	1,891	489	3,003
Amu	1,051	8,334	818	6,845
Thana	626	5,439	554	4,167
Sorghum	1	2	11	48
Green Gram	705	4,482	594	3,883
Cowpea	326	2,885	350	1,983
Horsegram	258	1,892	322	2,268
Other Pulses	89	707	26	240
		Cwt.		*Cwt.*
Manioc	12,735	763,705	13,261	559,500
Sweet Potatoes	3,045	179,100	5,761	86,628
Potatoes	8	572	—	—
Other edible root crops	1,043	18,569	852	18,686
Chillies	1,717	11,774	134	10,528
Mustard	127	719	100	495
Onion	548	5,319	344	2,374

Annual Crops

Rice (*Oryza sativia*), being the staple food of the people, is cultivated more for food than to derive profit on its cultivation. Work on plantations gave the labouring classes a regular income and therefore paddy cultivation did not receive the attention and effort it required. The increased price of Rs. 12 per bushel has created the incentive to adopt improved methods. The two main seasons are the *maha* and *yala*. The cultivation of six month varieties commences in August. If the inter-monsoonal rains fail, a four-month variety is cultivated. In the *yala* season, 3–4 month varieties are grown on account of the short season. There are several areas where only a long-aged variety of paddy is grown for *maha*, and the land left fallow in *yala*. In the Balangoda region 4-month varieties are grown both for *maha* and *yala*. Embilipitiya-Kaltota regions are typical dry zone areas ; 4-month varieties are grown for *maha* and 3-month varieties for *yala*. With the transfer of food production staff to the supervisory control of the Agricultural Officers in 1950, paddy cultivation received an impetus in regard to the adoption of improved cultural methods. The District Advisory Committee launched vigorous drives for the adoption of improved methods by demonstrations, competitions between Rural Societies, Mahila and Kantha Samities, and groups of cultivators. Transplanting was shown to be cheaper by speed competitions. Mass transplanting in villages where the rural population, school children and members of rural societies actively participated was a feature. The presence of distinguished personages was a source of encouragement and gave the occasion the importance a food production drive should have in the country. Mass harrowing with the use of subsidized fertilizers on large acreages has resulted in increased yields.

Pure line paddy. The most popular pure lines in long-aged tracts are *Podiwi* 8 and *a-Ptb* 16 for *maha ; Vellaiillanka-yalan* and *Pachchaiperumal* in the *maha* and *yala* respectively in the drier areas of the Province in Balangoda and Embilipitiya. The use of organic manures is generally practised but the quantities used are inadequate. Artificial fertilizers (wet zone mixture) are used extensively and the subsidy has added to its popularity. The cultivation of paddy according to the Japanese method is becoming popular, though slowly, on account of the extra cost and effort required.

Table V—Cultivated Extent of Paddy (Average for 3 years)

	Major Schemes		*Minor Schemes*		*Rainfed*		*Total*	
	Maha Acres	*Yala Acres*	*Maha Acres*	*Yala Acres*	*Maha Acres*	*Yala Acres*	*Maha Acres*	*Yala Acres*
Ratnapura	957	1,391	7,436	10,003	16,990	10,304	18,383	21,698
Kegalla	—	2,348	3,364	2,339	22,699	15,575	26,063	17,914

Table VI—Improved Practices in Paddy Cultivation

KEGALLA DISTRICT—

Improved Methods	*Maha 1951–52 Acres*	*Maha 1952–53 Acres*	*Maha 1953–54 Acres*	*Maha 1954–55 Acres*
Light Iron ploughing	1,095	1,967	3,737	5,254
Fertilizers	2,043	3,527	12,849	17,797
Pure seed	513	1,238	2,533	5,915
Transplanting	1,535	2,992	9,436	13,283
Japanese method	—	—	—	—
Crop harrowing	519	1,327	2,368	3,626

	Yala 1951 Acres	*Yala 1952 Acres*	*Yala 1953 Acres*	*Yala 1954 Acres*
Light Iron ploughing	248	1,072	1,891	2,668
Fertilizers	503	1,578	2,742	8,546
Crop harrowing	199	713	1,319	3,406

RATNAPURA DISTRICT—

Improved Methods	*Maha 1951–52 Acres*	*Maha 1952–53 Acres*	*Maha 1953–54 Acres*	*Maha 1954–55 Acres*
Light Iron ploughing	157	1,345	1,742	1,742
Fertilizers	5,102	2,129	7,462	7,462
Transplanting	2,003	2,000	2,250	1,250
Weeding	1,581	1,103	2,243	2,243
Pure Seed	—	2,100	2,500	2,576
Crop harrowing	2,003	1,252	1,333	1,253

Table VII—Paddy Yields

	Maha 1951–52	*Yala 1952*	*Maha 1952–53*	*Yala 1953*
	Bushels per Acre			
Ratnapura	24·82	24·0	29·50	22·10
Kegalla	30·83	29·15	30·73	24·93

	Maha 1953–54	*Yala 1954*	*Maha 1954–55*	*Yala 1955*
	Bushels per Acre			
Ratnapura	24·65	28·58	26·42	32·18
Kegalla	36·35	34·52	42·15	30·78

Livestock

Animal husbandry is restricted to areas where pasture is available. Except for a few dairies near the towns, Sinhala, Cross-bred and Indian cattle are kept to meet the requirement of milk for village homes, hotels and hospitals. On estates, European planters keep pure-bred and crossed Ayrshire and Friesians. Pasture land is limited on account of the major part of the province being under plantation crops. The local indigenous buffalo is used for paddy cultivation. Small quantities of buffalo milk are produced in the villages. Goat keeping is adopted in the dry zone regions of the Province. Poultry keeping is generally the occupation of the non-Buddhist population. Small flocks of R.I.R. and Australops are kept by some villagers.

	Ratnapura	*Kegalla*
Cattle ..	41,383	40,992
Buffaloes ..	9,806	22,831
Goats ..	11,976	20,625
Pigs ..	647	1,383
Fowls ..	94,173	83,972
Ducks ..	1,049	1,093
Turkeys ..	294	274
Bee Hives ..	176	768

The Agricultural Department has initiated various schemes to encourage small holders to up-grade their cattle and increase milk production. The first is by the establishment of stud centres where Scindi bulls are made available free to *bona fide* villagers and at a charge of Rs. 2 from others. In the case of an European breed, the charge is Rs. 5 per service. Stud bulls are issued to societies, village committees and individual breeders. Other methods adopted by the Department are the issue of heifers to peasant allottees, the sale of Scindi and Ayrshire bull calves to breeders, and the issue of bull calves under an exchange scheme to all. In Kegalla, the response has been very great on account of the possibility of keeping cattle on coconut estates. All those who were interested in cattle breeding became members of the Cattle Breeder's Association which also published a quarterly called the Stock Breeder. Annual district and village livestock shows were held. Milk marketing centres were organised to dispose of the surplus milk. The Kegalla District Agricultural Committee initiated the scheme of exemption under the Food Production Ordinance for livestock breeding by the planting community. The Tract Breeding Scheme was launched in 1953 by establishing stud centres in Beligal Korale. These centres were five miles apart so that a village breeder could conveniently bring his cows for service. At these centres, pasture and fodder grass planting material were made available ; veterinary and first aid treatment was also given. The castration of unfit males was done only to eliminate poor breeding stock. Artificial insemination has made slow progress, but breeders are beginning to feel the advantages of up-grading their stock by this method. It was essential to carry out more extensive propaganda before artificial insemination could be successfully undertaken. In 1953, a Veterinary Dispensary was established in Kegalla for free service to the public in 1954, one was established at Ratnapura. At these centres, minor ailments are treated, and advice on health and disease are given. They are also the headquarters for artificial insemination work.

Small Holdings, Gardens and Chenas

The development of highland small holdings other than plantation crops has been restricted to the valleys and

Table VIII—Livestock Improvement

	Ratnapura			*Kegalla*		
	1952	*1953*	*1954*	*1952*	*1953*	*1954*
CATTLE—						
1. Stud Centres	6	8	8	3	3	1
2. Stud Services	237	773	756	340	207	54
3. Artificial Insemination	—	—	125	—	—	49
4. Castration	180	243	239	103	379	381
5. Stud Bulls exchanged	—	—	10	—	—	6
POULTRY—						
1. Setting eggs sold	4,301	1,978	2,466	2,213	2,256	3,053
2. Cockerels and Chicks issued	767	95	168	244	8	122
3. Birds vaccinated against Ranikhet	11,969	9,760	5,298	11,340	32,212	53,813

hill slopes bordering the streams and rivers that arise from the central regions. Due to erosion over a long period, the valleys have become fertile. Families have settled in these areas and found employment on neighbouring estates. The larger number of holdings exists in the Kegalla District, viz., 43,968, while in Ratnapura there are 23,339 holdings. Such holdings are generally one acre or less in extent and carry some form of cultivation surrounding the dwelling houses. These gardens contain a mixed growth of kitul, jak, breadfruit, coconuts, arecanuts, plantains, limes, papaw and several species of self sown trees from the adjoining forest. In a number of villages, kitul trees are tapped illicitly for toddy which is sold to Tamil estate labourers. In areas which are further away from estates, jaggery making has been another source of revenue. The greater number of the *chenas* is in the dry zone where kurrakan, maize, gingelly, chillies, mustard are the common crops. Hill paddy, vegetables and root crops, cowpea, green gram are grown in wet zone *chenas*. The total acreage of both the wet and dry zone *chenas* is about 3,668 acres.

Other Trades

In Kukul, Atakalan and Kolonne Korales, villagers find employment in the Forest Department by felling and sawing forest trees. There is also a great deal of illicit felling of timber by the villagers themselves. Gem mining is another trade of the local inhabitants who organise themselves into groups and camp out for several weeks, excavating lands in the valleys and sieving the sands of river beds in search of gems. This is an occupation which has been a source of revenue to capitalists as well. Several persons have acquired wealth while others have been driven to poverty on account of the speculative nature of this trade.

Marketing has been a problem on account of the hilly nature of the country. There are restrictions on the use of estate roads. The small boutique keepers on estates profit considerably by acting as middlemen for the sale of produce brought by villagers from the more remote areas. At certain centres where fairs and markets are organized, the produce is collected and conveyed in lorries to Colombo.

Some Aspects of Dry Farming in the Canadian Prairies with references to Dry Farming in Ceylon

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(This note is based on the observations made and information gathered by the writer in Western Canada during a study programme arranged by the Canadian Government in the Summer of 1954, under the auspices of the Colombo Plan.)

Rainfall. The annual average rainfall in the Canadian Prairies is about 14 inches inclusive of the snowfall, 10 inches of which gives 1 inch of rain. About 50 per cent. of this precipitation occurs during the months of April, May, June and July. This period is referred to as the growing season when the most rapid growth of plants takes place. The favourable distribution of rain during the growing season helps the cultivation of grain crops a great deal. In contrast to this, although the minimum rainfall in the dry zone of Ceylon is thrice that of the average in the prairies, the distribution is poor for successful crop production. High evaporation is also a factor which adds to the difficulties of dry farming in the prairies, and this applies equally well to Ceylon.

Soil. The soil types vary from sandy loams to heavy clays, known as "gumbo soils". These gumbo soils are similar to the heavy clay soils found in Murunkan in the Mannar District of Ceylon. The light soils are somewhat similar to the soil types in Galoya Valley in the Eastern Province of Ceylon.

Moisture Conservation. It is said that the maximum conservation possible under the very best conditions is about 25 per cent. of the total precipitation. Experiments carried but by the Federal Department of Agriculture, Canada, have shown that in the case of wheat, the yield has been less than 14 bushels per acre when less than 10 inches of water have been used by the crop. When the water used was above 10 inches, for each additional 1 inch of water used, there was an increase of 6 bushels of wheat per acre.

The general practice in the prairies to conserve the moisture, is to summer fallow the land every second or third year. If a farmer has 2,000 acres under dry farming, he rests 1,000 acres and cultivates the balance one year, and continues the practice, rotating the land the following year and so on. A summer fallow is used mainly to conserve moisture by storing in the soil as much of the rain that falls in the year, to be used the following year by the crops grown on it. Any weed or plant growth during the fallow period is checked by a suitable tillage implement such as a disc tiller, and the land is kept clean cultivated. This results in storing in the soil as much as possible, of moisture that would otherwise, have been used by

weeds. Also, it gives a clean and beautiful stand of crops almost free from weeds the next year. In summer, it is a common sight to see a uniform stand of wheat free from weeds in almost any part of the prairies where summer fallowing is practised properly and good seed is used.

A summer fallow has the drawback of keeping the land idle for one year without a crop. To overcome this experiments were carried cut by the Department of Agriculture, Canada, by having intercultivated crops as a substitute for summer fallow. It was found that intercultivated crops use practically all the available moisture, thereby defeating the main purpose of having a summer fallow.

The practice of growing wind belts also exists in the prairies. Wind belts help in conserving the moisture by decreasing the wind velocity, thereby reducing evaporation from the soil and transpiration from the crops. The roots of the trees grown as wind belts reduce the moisture of the soil to some extent, but in Canada this is offset by the accumulation of snow around the trees during the winter.

Use of Commercial Fertilizers. Experiments with the application of commercial fertilizers are still being carried out by the Federal Department of Agriculture, Canada. According to the results available there seems to be no favourable response to the application of commercial fertilizers. A legume crop such as sweet clover is grown very often in rotation with the cereal crops. Sweet clover plant is similar to the "Pila" plant (*Tephrosia Purpurea*), also a legume, growing wild in the abandoned *chenas* in the dry zone of Ceylon. It is this "Pila" plant which is valued so highly by the enterprising farmers of Northern Ceylon that truck loads are transported over a distance of 125 miles or more to be used as green manure for their fields.

Control of Soil Erosion. Unlike in the dry zone of Ceylon, where heavy downpours occur during the early part of the *maha* season in October, November and December, causing soil erosion problems, there is no serious erosion of soil by water in the prairies. As such, there are no contour ridges or Mangum terraces, &c., to check water erosion. But soil erosion by wind is a serious problem in the prairies.

The control of wind erosion is mainly effected by checking the velocity of wind at ground level by obstructions such as clods in heavy soils, stubble, ridges made by a duckfoot cultivator, and strip farming. Wind erosion is more severe in light soils than in heavy clays. The disc harrow which breaks the clods is seldom or never used in dry farming in the prairies. Tillage of light soils is avoided until there is sufficient moisture in the soil for clod formation. The influence of organic matter in clod formation cannot be overemphasized.

Crop residues left on fallow land, check wind erosion of fine soil particles to a considerable extent; the land is never kept ploughed and disc harrowed. It is becoming a common practice to check wind erosion by keeping stubble and crop residues on land kept fallow and unploughed. Keeping the length of the stubble as long as possible by cutting the crop as high as possible is commonly practised to cause a greater reduction in wind velocity at ground level. Using a duckfoot cultivator to make small ridges

and furrows is also common to some extent. Where ridging is combined with crop residue and stubble, the beneficial effects are said to be more marked than when ridging alone is done.

Strip farming where strips of cereal crops alternate with strips of fallow, is also quite commonly practised to check wind erosion and trap the fine particles of moving soil. Usually, the fallow strips are narrower on sandy soils than clay soils.

Mechanisation of Agricultural Operations. The horse is no longer used on dry farms. The plough and the disc harrow are generally not used for tillage operation. The most common tillage implement is the one way disc commonly called the disc tiller in Ceylon. This implement is popular in dry farming in Ceylon too. The one way disc with the seed box attachment helps the farmer to sow his crops right away on summer land during spring. Crops sown on summer-fallowed land grow with hardly any competition from weeds, and this makes it unnecessary to do any intercultivation during the growing period. Also a farmer gets a fine uniform stand of crops provided he uses good seed. When the crop is ready for harvesting, straight combining is done to gather the harvest.

On summer-fallowed land, the common tillage implement used to control weeds is the disc tiller, the cultivator or a large duck foot sweep known as the Noble blade.

The equipment used by the farmer depends on the extent of cultivated land and the types of crops grown by him. The smallest economical unit appears to be about 1,200 acres of which only 600 acres are farmed during any year, the balance being summer-fallowed. A dry land farmer owning 2,000 acres usually keeps 5-6 tractors and two combines in addition to the trucks and tillage implements used by him. Labour is very scarce in the prairies, and usually all farm operations are handled by the farmer and his family with two or three extra hands hired to help him in the peak period of the cultivation season. These extra hands are kept on until the heavy work is over and then released as they will not be required again until the following year. Cropping is only done in the spring and summer seasons, from April to September. Minor repairs and maintenance of the machinery are attended to by the farmer himself.

A farmer sometimes has his own bins to store the grain or else he will sell his produce direct to the co-operative pool which maintains elevators for storing grain. In some areas there are grain elevators maintained by the Government. In 1954, the grain elevators in the prairies were full with surplus grain having about 400 million bushels of wheat alone ready for sale abroad. There appears to be some difficulty in finding a suitable market for this surplus wheat which is said to be excellent in quality.

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